(2)

USAAEFA PROJECT NO. 84-13

AD-A178 194

EVALUATION OF THE OV - 1D STALL WARNING CHARACTERISTICS

ROBERT D. ROBBINS
PROJECT OFFICER/TEST PILOT

JEFFREY L. LINEHAN
PROJECT ENGINEER

GEORGE M. YAMAKAWA
PROJECT ENGINEER

USAAEFA

JANUARY 1986

FINAL REPORT

Approved for public release, distribution unlimited.

UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

DISCLAIMER NOTICE

The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

DISPOSITION INSTRUCTIONS

Destroy this report when it is no longer needed. Do not return it to the originator.

TRADE NAMES

The use of trade names in this report does not constitute an official endorsement or approval of the use of the commercial hardware and software.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER USAAEFA PROJECT NO. 84-13	2. GOVT ACCESSION NO. AD-A178 194	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EVALUATION OF THE OV-1D STALL WARNING CHARACTERISTICS		5. TYPE OF REPORT & PERIOD COVERED FINAL 5 OCT 1985-28 OCT 1986
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) ROBERT D. ROBBINS JEFFREY L. LINEHAN GEORGE M. YAMAKAWA		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US ARMY AVN ENGINEERING FLIGHT ACTIVITY EDWARDS AIR FORCE BASE, CA 93523-5000		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS EJ-4-AHO-01-EJ-EC
11. CONTROLLING OFFICE NAME AND ADDRESS US ARMY AVIATION SYSTEMS COMMAND 4300 GOODFELLOW BOULEVARD ST. LOUIS, MO 63120-1798		12. REPORT DATE JANUARY 1986
		13. NUMBER OF PAGES 94
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

High Angle of Attack
Louvered Scarfed Shroud Suppressor
OV-1D(C)
Prototype Stall Warning System
Stall Characteristics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A high angle of attack flight and stall characteristics evaluation of the OV-1D(C) surveillance airplane (USA S/N 62-5867) was conducted by the US Army Aviation Engineering Flight Activity. The aircraft was equipped with a Safe Flight Instrument Corporation (SFIC) prototype stall warning system. Tests were flown with and without external aircraft mission/survivability equipment including the Louvered Scarfed Shroud Suppressor (LSSS) used for engine infrared signature suppression. The evaluation was conducted at Edwards Air

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(over)

(cont.)

Force Base and Point Mugu Naval Air Station, California. A total of 75.7 ~~hours~~ (44.9 productive hours) were flown between 5 October 1984 and 28 October 1985. Dual and single-engine unaccelerated stall, dual-engine accelerated stall, minimum trim airspeed, and static and dynamic single-engine minimum control airspeed (V_{mc}) tests were conducted over a range of gross weights and center of gravity locations. Evasive maneuvers and operational pilot evaluations of the SFIC stall warning system were also conducted. The dual and single-engine unaccelerated stall speeds and dual-engine accelerated stall speeds were not significantly affected by installation of the LSSS. Dual-engine flight idle power unaccelerated and accelerated stall speed data were essentially in agreement with the operator's manual flight idle power stall speed chart. The minimum single-engine control speed data differ significantly from the operator's manual. 2nd ~~Additionally,~~ there is no accurate maximum single-engine power stall speed data in the operator's manual. The SFIC stall warning system provided adequate aural and tactile stall warning margins in all cases except as noted below. Two deficiencies and one shortcoming were identified. The deficiencies were lack of an adequate prestall warning without an artificial stall warning system and insufficient artificial stall warning margin in the simulated left engine inoperative and propeller unfeathered configuration.

TABLE OF CONTENTS

APPENDIXES

DISTRIBUTION

INTRODUCTION

BACKGROUND

1. Previous tests conducted by the United States Army Aviation Engineering Flight Activity (USAAEFA) have shown OV-1D stall warning is inadequate. Reports from the field indicated that the LSSS degraded the stall characteristics. USAAEFA was tasked by the United States Army Aviation Systems Command (ref 1, app A) to conduct flight tests to determine the dual and single-engine stall characteristics, and the single-engine minimum control airspeed with the Louvered Scarfed Shroud Suppressor (LSSS) and external aircraft survivability equipment installed. In addition, a Safe Flight Instrument Corporation (SFIC) stall warning system was installed. The test scope was increased to evaluate the stall and stall warning characteristics during performance of evasive maneuvers developed by the US Army Intelligence School at Fort Huachuca, Arizona which are included in the Aircrew Training Manual FC 1-217 (ref 2, app A). The stall warning system was modified to correct problems found in the initial portions of this evaluation and further tests of the system were conducted.

TEST OBJECTIVES

2. The objectives of this test were to accurately define and describe the OV-1D high angle of attack dual and single-engine stall warning and stall flight characteristics and to determine single-engine minimum control airspeeds and minimum trim airspeeds with emphasis on the differences between the LSSS and non-LSSS equipped OV-1D. Prior to completing the tests, the objectives were expanded to include an evaluation of the SFIC stall warning system, a qualitative evaluation of the aircraft flight characteristics while performing the Aircrew Training Manual FC 1-217 evasive maneuvers, and evaluations by two operational pilots of the stall warning system.

DESCRIPTION

3. The test aircraft was an OV-1D(C), US Army Serial Number 62-5867, which had no operational mission airframe flight hours since conversion to a D model. The OV-1D is a two-place mid-wing observation/surveillance aircraft equipped with two T53-L-701 Lycoming gas turbine engines each rated at 1400 shaft horsepower at sea level standard day conditions. The test aircraft is shown in photographs 1 through 9, appendix B. The aircraft was flown in the Kit A (standard engine exhaust stacks) and Kit B (LSSS engine exhaust stacks) configurations with and without external mission equipment. The external mission equipment

configuration consisted of: a Radar Surveillance Set, AN/APS-94F pod (Side Looking Airborne Radar (SLAR) antenna), mounted on the right side of the fuselage; a self-contained infrared countermeasure set (IRCM), AN/ALQ-147A(V)1, mounted on wing store station 6; and two 150 gallon fuel drop tanks mounted on wing store stations 3 and 4. The aircraft was further configured with two AN/APR-44 radar warning antennae, mounted on the bottom of the fuselage and five AN/APR-39 radar signal detecting set antennae, one mounted on the bottom of the fuselage, two on the tail and two on the nose. The two AN/APR-44 radar warning antennae normally mounted on top of the center vertical fin were replaced by two video cameras. The wing tip caps were modified to accept the AN/APR-39 radar signal detecting set antenna. Additionally, the aircraft was flown with the SFIC angle of attack/stall warning system installed. The system included a lift transducer on the leading edge of the right wing (photos 10 and 11). An airspeed/angle of attack and sideslip boom was mounted on the SLAR antenna attachment points or on the SLAR antenna depending on the external store configuration being tested (photos 1, 3, 7 and 9). A detailed description of the test aircraft is contained in appendix B and in the operator's manual (ref 3, app A). The SFIC angle of attack/stall warning system is described in appendix B.

TEST SCOPE

4. An evaluation of the OV-1D stall characteristics was conducted at Edwards Air Force Base (AFB) and Point Mugu Naval Air Station, California. Evasive maneuvers and operational pilot evaluations were conducted at Edwards AFB. A total of 58 flights and 75.7 flight hours (44.9 productive flight hours) were conducted between 5 October 1984 and 28 October 1985. The angle of attack/stall warning system in the test aircraft was supplied and maintained by the SFIC. They also modified the stall warning system after the initial flight test results were analyzed. The tests were conducted in accordance with the test plan (ref 4, app A) in day, visual meteorological conditions and within the limits of the operator's manual and airworthiness release (ref 5). The stall warning margins were compared to the requirements of Military Specification MIL-F-8785C (ref 6) and the audible stall warning tone was compared to MIL STANDARD 411D (ref 7). Dual and single-engine unaccelerated stalls, dual-engine accelerated stalls, minimum trim airspeeds, and static and dynamic single-engine minimum control airspeed (V_{mc}) tests were conducted over a range of gross weights and center of gravity locations, landing gear, flap and power settings, and external store configurations.

The aircraft configurations are listed in table 1. The OV-1D flight characteristics were evaluated throughout these tests at the conditions shown in table 2.

TEST METHODOLOGY

5. Established engineering flight test techniques and data reduction procedures were used during this evaluation (refs 8 and 9, app A). The test methods are briefly described in the Results and Discussion sections of this report. A more detailed description of the test techniques and data analysis methods may be found in appendix D. Data were recorded on magnetic tape onboard the aircraft and via telemetry to the Real-Time Data Acquisition and Processing System (RDAPS) facility. Telemetry to the RDAPS was used to monitor critical parameters in flight. Appendix C contains listings of the test instrumentation. Tufts were affixed to the aircraft wing surfaces, including the area around the LSSS and engine nacelles, the vertical and horizontal tail surfaces, and the aft fuselage for aerodynamic analysis. Photographic documentation was accomplished with and without the LSSS installed and various store loadings using tail mounted video cameras and a UH-60A chase helicopter. Weight and balance, fuel cell calibration and flight control rigging checks were performed prior to the first flight. Deficiencies and shortcomings are in accordance with the definitions presented in appendix D.

Table 1. Aircraft Configuration

Aircraft Configuration	Landing Gear Position	Flap Setting (deg)	Power Setting		
			Dual-Engine Stall	Single-Engine Stall	Single-Engine Minimum Control
Takeoff (TO)	Down	15	Flight Idle, Takeoff	Flight Idle, Takeoff less 10% torque, Takeoff less 5% torque, Takeoff	Takeoff less 10% torque, Takeoff less 5% torque, Takeoff
Cruise (CR)	Up	Zero	Flight Idle, Takeoff	Flight Idle, Takeoff less 10% torque, Takeoff less 5% torque, Takeoff	Takeoff less 10% torque, Takeoff less 5% torque, Takeoff
Go-Around (GA)	Up	15	Flight Idle, 25%, Takeoff	Flight Idle, Takeoff less 10% torque, Takeoff less 5% torque, Takeoff	Takeoff less 10% torque, Takeoff less 5% torque, Takeoff
Landing (L)	Down	45	Flight Idle, 25%, Takeoff	Flight Idle, Takeoff less 10% torque, Takeoff less 5% torque, Takeoff	Takeoff less 10% torque, Takeoff less 5% torque, Takeoff

Table 2. Test Conditions - Stall Evaluation

Test	Trim Airspeed	Takeoff Gross Weight (lb)	Longitudinal C.G. Location (FS)	Pressure Altitude (ft)	Aircraft Configuration	Stores Configuration
Dual-Engine Unaccelerated Stall	$1.2V_{S1}$[1]	14,550	165.0 (Aft)	10,000	TO, CR[6], GA[7], L[7]	(2)
		14,650	165.0 (Aft)			(3)
		18,300	163.3 (Aft)			(4),(5)
		18,300	157.0 (Fwd)			(5)
Dual-Engine Accelerated Stall	$1.4V_{S1}$[1]	14,550	165.0 (Aft)	10,000	CR[8]	(2)
		14,650	165.0 (Aft)		CR[8]	(3)
		18,300	163.3 (Aft)		CR[8], TO[9]	(4),(5)
Single-Engine Unaccelerated Stall	V_{yse}[10]	14,550	165.0 (Aft)	10,000	TO, CR GA, L	(2)
		14,650	165.0 (Aft)			(3)
		18,300	163.3 (Aft)			(4),(5)
		18,300	157.0 (Fwd)			(5)
Single-Engine Minimum Control Airspeed	(11)	14,550	165.0 (Aft)	6,000	TO, CR GA, L	(2)
		14,650	165.0 (Aft)			(3)
		18,300	163.3 (Aft)			(4),(5)
		18,300	157.0 (Fwd)			(5)
Evasive Maneuvers	160	17,900	159.4 (Mid)	12,000	CR	(5)

NOTES:

[1] V_{S1}: Dual-engine power OFF stall airspeed for a specific aircraft configuration. Operator's manual recommended takeoff trim setting were used for the TO aircraft configuration.
[2] No stores, standard engine exhaust stacks.
[3] No stores, Louvered Scarfed Shroud Suppressor (LSSS) engine exhaust stacks.
[4] Two drop tanks, Infrared Countermeasures (IRCM) pod (wing station 6), and Side Looking Airborne Radar (SLAR) boom installed.
[5] Two drop tanks, IRCM pod (wing station 6), SLAR boom, and LSSS installed.
[6] Tests conducted with speed brakes extended at flight idle and takeoff power settings.
[7] Tests conducted with speed brakes extended at takeoff power setting.
[8] Tests conducted at 2.0g, 2.5g, and 2.75g.
[9] Tests conducted at 1.7g.
[10] V_{yse}: Single engine best rate of climb airspeed.
[11] Static minimum control airspeed (V_{MC}) tests were conducted at the trim setting required for minimum control forces using maximum power available on the operating engine. Dynamic minimum control airspeed trim conditions were established according to note 1 at 1.2 V_{S1}.

RESULTS AND DISCUSSION

GENERAL

6. The high angle of attack and stall characteristics of the OV-1D aircraft were evaluated in the non-LSSS and LSSS mission configurations. A prototype SFIC stall warning system was also evaluated concurrently with the stall tests. The dual and single-engine unaccelerated stall speeds and dual-engine accelerated stall speeds were not significantly affected by the installation of the LSSS. The dual-engine flight idle power unaccelerated and accelerated stall speed data are essentially in agreement with the operator's manual flight idle power stall speed chart. There is no accurate maximum single-engine power stall speed data in the operator's manual. The minimum single-engine control speed data differ significantly from the operator's manual. The stall warning system provided adequate stall warning margins when performing dual-engine stalls and single-engine stalls except for the deficiency noted below. The SFIC stall warning system provided adequate pilot cues to recover the aircraft prior to an aerodynamic stall while permitting the aircraft to be maneuvered at speeds slower than the onset of aerodynamic buffet. Two deficiencies and one shortcoming were identified. The deficiencies were lack of an adequate prestall warning without an artificial stall warning system and insufficient artificial stall warning margin in the simulated left engine inoperative and propeller unfeathered configuration. Recommend the following NOTE be incorporated in the operator's manual:

NOTE

> Unpredictable and inconsistent aerodynamic stall warning (prestall) buffet speed margins will be encountered with different aircraft configurations and power settings in both unaccelerated and accelerated flight conditions.

A discussion of aircraft prestall and stall characteristics in the LSSS configuration should be included in the operator's manual with the following NOTE:

NOTE

> In LSSS configured aircraft, airframe prestall buffet accompanied with left wing drop which requires approximately 1 to 1.5 inches of lateral stick displacement to maintain wings level may occur well above stall.

DUAL-ENGINE CHARACTERISTICS

General

7. Evaluation of the OV-1D dual-engine characteristics included unaccelerated stalls and accelerated stalls up to a load factor of 3.2. The unaccelerated and accelerated flight idle power stall airspeeds in the operator's manual are essentially in agreement with the test data.

Dual-Engine Unaccelerated Stalls

8. The dual-engine unaccelerated stalls were evaluated in the aircraft configuration shown in table 1 and at the test conditions shown in table 2. Flight control trim tabs were set for each aircraft configuration as defined in appendix D. The aircraft was decelerated at a rate of one knot indicated airspeed (KIAS) or less per second until the stall occurred.

9. Typically, for unaccelerated stalls in both the non-LSSS and LSSS configuration the stall was preceded by airframe buffet in most power, flap, and gear configurations. Stalls which were not preceded by airframe buffet occurred most frequently with power ON and flaps at 15 or 45 degrees. When decelerating at rates greater than one knot per second the aerodynamic prestall buffet did not occur in some flaps UP configurations. When airframe buffet occurred it was at a higher frequency in the LSSS configured aircraft than in the non-LSSS aircraft. Airframe buffet in the LSSS configuration was accompanied by a left wing drop prior to the stall which required approximately 1 to 1.5 inches of right lateral stick displacement in order to maintain wings level. Random wing rocking occurred after initiation of the prestall buffet and just prior to stall in both the LSSS and non-LSSS configurations but occurred more frequently in the LSSS configuration. The aerodynamic stall warning (prestall) buffet speed margin above stall was unpredictable and inconsistent with different aircraft configurations and power settings and was unreliable as a pilot cue for prestall warning. The inadequate prestall warning of the OV-1D without an artificial stall warning system is a deficiency.

10. Aerodynamic tuft analysis with the LSSS installed indicated prestall buffet occurs when the wing angle of attack increases to the point that the airflow across a portion of the wing upper surface separates. As the airspeed is decreased (angle of attack increased) the stalled area of the wing increases and propogates toward the wing tips until a point is reached at which the

remaining unstalled wing area cannot produce enough lift to support the aircraft weight and the aircraft stalls. When the prestall airframe buffet occurs, the local airflow on the upper wing surface outboard of the left engine nacelle separates from the wing at a higher airspeed than it does at the corresponding area on the right wing. This is possibly caused by a higher local angle of attack on the left wing outboard of the left engine nacelle due to the clockwise rotation of the left engine propeller and interference of the propeller slipstream with the LSSS. When the buffet occurs, there is a left roll tendency requiring approximately 1 to 1.5 inches of right lateral stick displacement to maintain wings level flight. There is also a significant decrease in aircraft performance with the onset buffet. As an example, there was no airframe prestall buffet at 110 KIAS using power required to maintain level flight. By decelerating one knot, the airframe buffet started and the aircraft experienced an approximate 400 feet per minute (fpm) rate of descent with no change in power. In order to stop the prestall buffet without a power change, the angle of attack must be decreased so that the turbulent flow can reattach to the wing upper surface. Thus the airspeed must be increased well above the buffet onset airspeed to stop the prestall buffet. In this example the airspeed was increased to 130 KIAS before the prestall buffet ceased.

11. Random rudder pedal oscillations occurred in the LSSS and non-LSSS configurations, with and without stores, with flaps down at torque settings above 35 percent with ball-centered or left of center. The oscillations stopped if the aircraft flight controls were retrimmed or rudder displaced to produce a slight right sideslip (i.e., ball right of center), flaps retracted, or power reduced below 35 percent torque. The amplitude was approximately $\pm 3/8$ inch at the pedal with a frequency of approximately 2 cycles per second. This characteristic has been observed in other OV-1D aircraft but is not common to the entire OV-1D fleet. The rudder pedal oscillation has been investigated by Grumman Aircraft Corporation and USAAEFA but the cause has not been determined. Although it is not considered a safety hazard, the rudder pedal oscillation with the flaps down and power above 35 percent torque is a shortcoming.

12. The direction of post-stall reaction was not dependent upon aircraft gear, flap, stores or LSSS configuration. Rather, it was affected primarily by the power setting. With power ON, a right roll at stall develops with or without a corresponding nose pitch down. In contrast, with power OFF, the aircraft tends to pitch down with little or no roll. Higher roll rates were observed without wing stores installed than with wing stores

regardless of LSSS configuration. The maximum roll rate observed at the stall without wing stores was 45 degrees per second and 34 degrees per second with wing stores installed.

13. A comparison of the dual-engine unaccelerated stall data to data presented in the operator's manual is shown in table 3. The dual-engine unaccelerated stall speeds were not significantly affected by installation of the LSSS. There were no significant differences in stall speeds and departure characteristics when performing stalls with the speed brakes extended as compared to speed brakes retracted. A summary of the dual-engine unaccelerated stall data is presented in tables 1 through 4, appendix E. The dual-engine flight idle power unaccelerated stall speed data are essentially in agreement with the operator's manual flight idle power stall speed chart.

Dual-Engine Accelerated Stalls

14. Dual-engine accelerated stalls were evaluated in the aircraft configuration shown in table 1 and at the test conditions shown in table 2. Flight control trim tabs were set for each aircraft configuration as defined in appendix D. The initial accelerated stall in each wing store configuration was performed using a wings level pull-up to determine the post-stall roll direction. In aircraft configurations in which the stall was accompanied with roll, the roll was always to the right. Right turns were determined critical since the post-stall reaction was in that direction and often resulted in recovering from the stall in a near inverted attitude which required greater normal accelerations and altitude loss during the recovery. Subsequent testing was performed utilizing wind-up turns to the left. There was no apparent difference in the coefficient of lift at the stall using either the pull-up, left or right wind-up turn technique.

15. Prestall flight characteristics during the accelerated stall evaluation were similar to those observed in the dual-engine unaccelerated stalls except the airframe buffet preceded the stall by a larger margin when performing accelerated stalls. The airspeed buffet margin prior to stall, however, was much greater and at a higher frequency with LSSS installed than without LSSS installed. Buffet onset occurred at 175 KIAS at 2.65g in the LSSS, cruise (CR) configuration with the stall occurring at 140 KIAS. Airframe buffet in the LSSS configuration was accompanied by a left wing drop prior to the stall which required approximately 1 to 1.5 inches of right aileron in order to maintain the same angle of bank. Slight random wing rocking occurred after initiation of the prestall buffet similar to that observed in the dual-engine unaccelerated stalls. OV-1 pilots

Table 3. OV-1D(C) Dual-Engine Unaccelerated Stall Performance Summary

Aircraft Configuration	Power Settings	Stores OFF		Stores ON	
		LSSS Effect	Change From Operator's Manual	LSSS Effect	Change From Operator's Manual
Cruise	Flight Idle	None	3 knots higher	None	3 knots higher
	Maximum Available	None	Note 1	None	Note 1
Takeoff	Flight Idle	None	2 knots lower	None	2 knots lower
	Maximum Available	None	Note 1	None	Note 1
Go-Around	Flight Idle	None	4 knots lower	None	4 knots lower
	Maximum Available	None	Note 1	None	Note 1
Landing	Flight Idle	None	3 knots lower	None	3 knots lower
	Maximum Available	None	Note 1	None	Note 1

NOTE:

[1]No operator's manual comparison data available

are trained to initiate recovery at the first physical indication of a stall such as uncontrollable pitching, buffeting, rapid decay of control effectiveness, or the application of full up elevator without producing further stall development. Performing stall recovery procedures during accelerated maneuvers at the onset of prestall buffet limits the aircraft performance and maneuver capabilities since the buffet may preceed the stall by as much as 35 KIAS in high g maneuvers. The inadequate prestall warning of the OV-1D without an artificial stall warning system is a deficiency.

16. The aircraft reactions at the stall in the non-LSSS configuration were more violent than those in the LSSS configuration. The accelerated stalls in the non-LSSS configuration were characterized by a right roll where as in the LSSS configuration the initial stall was characterized by a mild nose down pitch. A right roll would follow the nose down pitch in the LSSS configuration only if a recovery was not initiated immediately after the stall (i.e., forward stick to reduce angle of attack and to decrease the g). Roll rates greater than 55 degrees per second were recorded in both the LSSS and non-LSSS configured aircraft; however, in the LSSS configuration this roll departure occurred only after 2 or 3 mild nose down pitch breaks, which occurred at progressively higher g levels (approximately 0.1 g increase at each successive stall). The high roll rate in the non-LSSS configuration occurred at the initial stall pitch break. Regardless of the LSSS configuration, the post-stall roll rates were much higher without wing stores than with wing stores. The highest roll rate observed during the accelerated stalls with wing stores was 59 degrees per second compared to 74 degrees per second without wing stores.

17. A comparison of the dual-engine accelerated stall data to the operator's manual stall data is shown in table 4. The accelerated stall speeds were not significantly affected by installation of the LSSS. In the CR configuration at idle power the stall speeds were 3 to 4 KIAS higher than the operator's manual stall speed data. In the takeoff (TO) configuration at idle power the stall speed was 4 KIAS lower than the operator's manual stall speed data. A summary of the dual-engine accelerated stall data is presented in tables 5 and 6, appendix E. The dual-engine flight idle power accelerated stall speed data are essentially in agreement with the operator's manual flight idle power stall speed chart.

Table 4. OV-1D(C) Dual-Engine Accelerated Stall Performance Summary

Aircraft Configuration	Power Settings	Stores OFF		Stores ON	
		LSSS Effect	Change From Operator's Manual	LSSS Effect	Change From Operator's Manual
Cruise	Flight Idle	None	3 knots higher	None	4 knots higher
	Maximum Available	None	Note 1	None	Note 1
Takeoff	Flight Idle	---	-----	None	4 knots lower
	Maximum Available	---	-----	None	Note 1

NOTE:

[1]No operator's manual comparison data available.

SINGLE-ENGINE CHARACTERISTICS

General

18. Evaluation of the OV-1D single-engine characteristics included single-engine unaccelerated stalls and determination of static and dynamic V_{mc}. The flight critical inoperative engine was determined prior to performing the above tests. The critical engine is that engine which, when inoperative, with the operating engine at maximum power, results in the highest airspeed at which a loss of aircraft control or stall occurs. The left engine was the critical engine in all cases tested and was, therefore, either simulated inoperative (power lever at FLIGHT IDLE and propeller lever at MINIMUM RPM) or actually inoperative (propeller stopped and feathered) when conducting the single-engine stall and V_{mc} tests.

19. Installation of the LSSS on the OV-1D did not adversely affect the single-engine stall or V_{mc} airspeeds. There is no accurate maximum single-engine power stall speed data in the operator's manual. The single-engine minimum control speed chart in the operator's manual is inaccurate.

Single-Engine Unaccelerated Stalls

20. Single-engine unaccelerated stalls were evaluated in the aircraft configurations shown in table 1 and at the test conditions shown in table 2 with the left engine shutdown and the propeller feathered. Flight control trim tabs were set for each aircraft configuration as defined in appendix D and the aircraft was decelerated at one KIAS per second or less until the stall occurred. Single-engine stalls were performed using maximum available power, maximum power less 5 percent torque and maximum power less 10 percent torque on the right engine simulating possible differences in maximum power available. No significant differences in stall speeds or stall characteristics were observed with these variations in power.

21. The single-engine prestall flight characteristics were similar to the dual-engine prestall characteristics except that in the single-engine case the prestall buffet occurred more frequently in the LSSS configuration than in the non-LSSS configuration. The prestall buffet occurred much earlier in the CR configuration, both LSSS and non-LSSS configured, than in any other configuration tested. Single-engine unaccelerated stall characteristics varied with aircraft configuration, stores configuration, and power setting. At idle power in any aircraft or stores configuration the aircraft reaction at stall was a

mild nose down pitch with little or no roll. This post-stall reaction also occurred at any power setting, in any aircraft configuration with stores ON and LSSS installed. The aircraft rolled left and pitched down at the stall with power ON, LSSS installed, and stores OFF. The aircraft rolled right and pitched down in all other cases tested. The maximum roll rate observed without wing stores was 40 degrees per second as compared to 12 degrees per second with wing stores installed. Aileron ineffectiveness was noticed within 2 KIAS of the stall during the single-engine unaccelerated stalls in the go-around (GA) configuration at 73 and 78 percent (maximum available) torque and in the landing (L) configuration at idle power with the LSSS installed and the stores OFF. Immediately prior to and throughout the stall sequence the aircraft entered a left roll which could not be corrected with available lateral stick until angle of attack and power were reduced.

22. A comparison of the single-engine stall speeds to available operator's manual data is presented in table 5. The operator's manual does not include a chart which provides single-engine stall data; therefore, it is assumed that either the operator's manual stall speed charts apply to both dual and single-engine stalls or the minimum single-engine control speed chart applies to single-engine stalls. The single-engine unaccelerated stall data with idle power on the operating engine essentially agree with the operator's manual dual-engine flight idle power stall speed chart. The single-engine unaccelerated stall data using maximum available power is approximately 10 KIAS higher than the dual-engine unaccelerated stall test data. The operator's manual does not contain a maximum dual-engine power stall chart; therefore, no comparison data was available. However, significant differences are apparent when comparing the single-engine unaccelerated stall data using maximum available power to the operator's manual minimum single-engine control speed chart. The single-engine unaccelerated stall data using maximum available power in the TO configuration are 7 to 9 KIAS lower and in the CR configuration are 13 KIAS lower than the operator's manual minimum single-engine control speed chart data. A summary of the single-engine unaccelerated stall data is presented in tables 7 through 10, appendix E. The single-engine unaccelerated stall speeds were not significantly affected by installation of the LSSS. There is no accurate maximum single-engine power stall performance data in the operator's manual. Single-engine stall performance data should be included in the operator's manual.

Single-Engine Minimum Control Airspeed

23. Static and dynamic V_{mc} evaluations were conducted in the aircraft configurations and at the test conditions shown in

Table 5. OV-1D(C) Single-Engine Unaccelerated Stall Performance Summary

Aircraft Configuration	Power Settings	Stores OFF			Stores ON		
		LSSS Effect	Change From Operator's Manual		LSSS Effect	Change From Operator's Manual	
			Stall Speed Chart	Minimum Single-Engine Control Speed Chart		Stall Speed Chart	Minimum Single-Engine Control Speed Chart
Cruise	Flight Idle	None	3 knots higher	Not applicable	None	3 knots higher	Not applicable
	Maximum Available	None	Note 1	13 knots lower	None	Note 1	13 knots lower
Takeoff	Flight Idle	None	2 knots lower	Not applicable	None	3 knots lower	Not applicable
	Maximum Available	None	Note 1	7 knots lower	None	Note 1	9 knots lower
Go-Around	Flight Idle	None	3 knots lower	Note 1	None	3 knots lower	Note 1
	Maximum Available	None	Note 1		None	Note 1	
Landing	Flight Idle	None	Same	Note 1	None	Same	Note 1
	Maximum Available	None	Note 1		None	Note 1	

NOTE:

[1]No operator's manual comparison data available.

tables 1 and 2, respectively. A definition of static and dynamic V_{mc} as well as a description of how the flight control trim tabs were set for each aircraft configuration may be found in appendix D. The static V_{mc} tests were conducted with the critical (left) engine shutdown, propeller feathered and decreasing the airspeed at a rate of one KIAS per second or less while maintaining up to 5 degrees bank angle toward the operating engine. Dynamic V_{mc} tests were performed by rapidly reducing the critical (left) engine power lever to idle followed by reducing the propeller lever to minimum rpm simulating a sudden engine failure in the TO configuration with the propeller automatically feathering. The propeller lever was left at maximum rpm for simulated engine failures in the CR, L and GA configurations since the autofeather would not be armed in these cases. Flight control inputs were delayed for one second following the simulated engine failure to simulate pilot reaction time. This procedure was repeated at successively slower airspeeds until the minimum airspeed was reached at which a straight flight path could be maintained.

24. There were no significant effects of power on V_{mc} speeds at maximum available power, maximum power less 5 percent torque and maximum power less 10 percent torque. Effects of the LSSS on the static and dynamic V_{mc} airspeeds and comparision to available operator's manual data is summarized in tables 6 and 7. The static V_{mc} speeds were not affected by the LSSS installation except in the TO configuration with maximum power in which case the V_{mc} speed was 4 KIAS lower with the LSSS installed than without LSSS. The test data shows static V_{mc} speeds 5 KIAS to 13 KIAS lower than the operator's manual V_{mc} speed charts. The dynamic V_{mc} speeds were not affected by the LSSS installation. The test data shows dynamic V_{mc} speeds 2 KIAS to 8 KIAS lower than the operator's manual. V_{mc} was defined by stall or simultaneous stall and loss of directional control regardless of LSSS configuration in all aircraft configurations tested except the CR configuration without stores where it was defined by a loss of directional control with full rudder pedal input (classic V_{mc} departure). It is important for the pilot to realize that during single-engine operation loss of aircraft control due to reaching V_{mc} may occur prior to or at a higher airspeed than a stall will occur. A stall warning device can not be used to warn the pilot that the aircraft is approaching this type of V_{mc} situation. A summary of static and dynamic V_{mc} data is presented in tables 11 through 14, appendix E. The single-engine minimum control speed data in the operator's manual is inaccurate; although, the inaccuracies are in a conservative direction compared to the test data. The single-engine minimum control speed data in the operator's manual should be updated and represent the dynamic V_{mc} conditions.

Table 6. OV-1D(C) Static Single-Engine Minimum Control Airspeed (V_{MC}) Performance Summary

Aircraft Configuration	ower Settings	Stores OFF		Stores ON	
		LSSS Effect	Change From Operator's Manual	LSSS Effect	Change From Operator's Manual
Cruise	Maximum Available	None[1]	13 knots lower	None[2]	13 knots lower
Takeoff	Maximum Available	4 knots[2] lower	5 knots lower	None[2]	9 knots lower
Go-Around	Maximum Available	None[2]	Note 3	None[2]	Note 3
Landing	Maximum Available	None[2]	Note 3	None[2]	Note 3

NOTES

[1]Static V_{MC} defined by loss of directional control.
[2]Static V_{MC} defined by stall.
[3]No operator's manual comparison data available.

Table 7. OV-1D(C) Dynamic Single-Engine Minimum Control Airspeed (V_{MC}) Performance Summary

Aircraft Configuration	Power Settings	Stores OFF		Stores ON	
		LSSS Effect	Change From Operator's Manual	LSSS Effect	Change From Operator's Manual
Cruise	Maximum Available	None	6 knots lower	None	6 knots lower
Takeoff	Maximum Available	None	2 knots lower	None	8 knots lower
Go Around	Maximum Available	None	Note 1	None	Note 1
Landing	Maximum Available	None	Note 1	None	Note 1

NOTE:

[1]No operator's manual comparison data available.

TRIMMABILITY

25. The aircraft trimmability was evaluated to determine the minimum speed at maximum power which could be flown using the available trim control range and to verify that the aircraft could not be trimmed into a stall in coordinated unaccelerated flight. Minimum trim airspeeds were obtained both dual-engine and single-engine with the left engine shutdown and propeller feathered. A summary of the test conditions and minimum trim airspeeds are presented in tables 15 and 16, appendix E. Minimum trim airspeeds were determined by trimming the aircraft at maximum power using only the trim wheel controls. The airspeed at which the aircraft flight path could no longer be controlled solely through the use of the flight control trim tabs was defined as minimum trim airspeed. Dual and single-engine primary flight control positions and trim wheel positions at trim are presented in tables 17 and 18, appendix E. The limiting trim control in all cases was rudder. No condition was observed which allowed the aircraft to be trimmed into a stall while using maximum power and coordinated (ball-centered) flight. The dual-engine minimum trim speeds in the LSSS configuration were 1 to 6 KIAS higher than the non-LSSS configuration over the range of test cases and are satisfactory. The single-engine minimum trim speeds in the LSSS configuration were 4 KIAS lower to 10 KIAS higher than the non-LSSS configuration over the range of test cases and are satisfactory.

EVASIVE MANEUVERS

26. Aircraft evasive maneuvers were performed to evaluate aircraft handling qualities and the stall warning system while executing typical tactical mission maneuvers which require the aircraft to be operated near the limits of its maneuvering envelope. These maneuvers as they would be performed in a tactical environment are described in the surveillance airplane Aircrew Training Manual (ATM) (ref 2, app A). The execution of these maneuvers was slightly modified to include retaining the wing stores throughout the maneuver and descending to a predetermined safe altitude (5000 feet above ground level) rather than an extremely low altitude for the maneuvers which specify utilizing a rapid descent to achieve a minimum altitude to gain terrain masking. A brief description of the evasive maneuvers performed for this evaluation may be found in appendix D. The test conditions for this evaluation are shown in table 2.

27. All maneuvers were entered from level cruise flight with 60 to 65 percent torque and an airspeed of 155 to 160 KIAS at an altitude of approximately 12,500 feet pressure altitude. Cruise power

settings were maintained throughout the maneuver unless required to be reduced to avoid going beyond the never exceed airspeed (V_{NE}). All of the evasive maneuvers resulted in a rapid loss of altitude with the exception of the "jink" maneuver. Rates of descent in excess of 20,000 fpm were common during the maneuvers and reached near 30,000 fpm in the "split S" maneuver with a maximum airspeed of 320 KIAS. Flight control trim positions remained at the cruise setting entry conditions throughout the maneuvers. This resulted in high forward stick forces as the airspeed increased which caused negative stick force per g (i.e., a forward stick force as g increases) during the airspeed increase and recovery to level flight. Retrimming the elevator to eliminate the longitudinal stick forces was not feasible due to the rapid airspeed changes during descent and recovery to level flight. Thus the aircraft can easily exceed the load factor limits unless the g meter is closely observed during the recovery. The aircraft normal acceleration limit is increased by 0.43g for symmetric wing loading and 0.34g for asymmetric wing loading (rolling maneuvers) if full drop tanks and the AN/ALQ-147A(V)1 are jettisoned. However, this increased normal acceleration limit after jettisoning the external stores is not considered significant. A pilot's attention will be outside the aircraft when performing these maneuvers in an actual threat environment thus the g meter cannot be monitored. There is high potential for exceeding the aircraft normal acceleration limitations when performing the evasive maneuvers outlined in the OV-1 Aircrew Training Manual during actual threat evasion. The aircraft normal acceleration limitations should be reviewed to ascertain if the symmetric and asymmetric g envelope can be substantially increased permitting higher normal acceleration limits for actual threat evasion.

28. The only evasive maneuver which approached a stall was the "jink" maneuver. The stall warning pedal shaker was detectable above the heavy airframe buffet occurring prior to the stall; however, the audio stall warning tone was the primary cue to decrease the severity of the maneuver by decreasing the g thus preventing a stall. A stall will occur if the maneuver is continued with increasing g or decreasing airspeed beyond the stall warning system activation point. The initial stall is characterized by a mild nose down pitch; however, if the g level is not decreased a secondary stall will occur which will result in a right roll (ref para 16).

ANGLE OF ATTACK/STALL WARNING SYSTEM

General

29. The test aircraft was equipped with a modified SFIC SC200 stall warning system throughout the stall characteristics evaluation. The system was evaluated throughout the conduct of the tests in the aircraft configurations in table 1 and at the test conditions shown in table 2. Based on the system operation during the stall evaluation, modifications were made to the SFIC system and tests were performed to verify the stall warning system's capability to provide an adequate and reliable prestall warning signal to the pilot. SFIC stall warning system changes which resulted from the initial evaluation consisted of adding an aural stall warning tone to backup and enhance the rudder pedal shaker warning, increasing vibration amplitude of the rudder shaker to reduce masking caused by heavy airframe buffet in accelerated stalls, eliminating the cockpit angle-of-attack gauge which had proven to be inconsistent and too sensitive in turbulent air conditions to be used as a stall warning device or aid in performing power approaches and precision landings, moving the lift transducer three inches inboard on the right wing leading edge due to wing deice boot considerations, and modifying computer software to increase the stall warning margin for configurations in which the margin was too small. The modified SFIC stall warning configuration consisted of a lift transducer mounted on the leading edge of the right wing outboard of wing store 6, a lift computer, a manually operated flap position switch, a manually operated weight-on-wheels switch, a rudder pedal shaker mounted on the pilot's left pedal and a 700 Hertz (Hz) aural tone generator electrically connected to the pilot's and copilot's intercom system. A more detailed description of the SFIC stall warning sytem and photographs of various components are found in appendix B.

30. The modified stall warning system was evaluated and test results were compared to the requirements of Military Specification, MIL-F-8785C and Military Standard, MIL STANDARD 411D. This evaluation was conducted in the aircraft configurations listed in table 1 and at the conditions shown in table 8. The test points in table 8 represent those conditions during the initial stall evaluation in which the stall warning margin was near the military specification limits or conditions that were of particular interest.

31. Stall and SFIC stall warning data with the modified system are presented in tables 19 through 27, appendix E. A comparison of the stall warning margin data to the military specification

Table 8. Test Conditions - Stall Warning System Evaluation[1]

Test	Trim Airspeed	Takeoff Gross Weight (lb)	Takeoff Longitudinal Center of Gravity (FS)	Pressure Altitude (ft)	Aircraft Configuration	Stores Configuration
Dual-Engine Unaccelerated Stall	$1.2V_s$[2]	15,200	159.9 (Mid)	10,000	TO CR L	None
		17,500	160.4 (Aft)			Two (2) 150 gallon drop tanks
		18,300	157.0 (Fwd)			SLAR[3], two (2) 150 gallon drop tanks, AN/ALQ-147(V)1 (store Station 6)
			163.0 (Aft)			
Single-Engine Unaccelerated Stall	V_{yse}[4]	15,200	159.9 (Mid)		TO CR GA L	None
		17,500	160.4 (Mid)			Two (2) 150 gallon drop tanks
		18,300	157.0 (Fwd)			SLAR, two (2) 150 gallon drop tanks, AN/ALQ-147(V)1 (store Station 6)
			163.0 (Aft)			
Dual-Engine Accelerated Stall	$1.4V_{s1}$[2]	15,200	159.9 (Mid)		TO[5] CR[6]	None
		17,500	160.4 (Mid)			Two (2) 150 gallon drop tanks
		18,300	157.0 (Fwd)			SLAR, two (2) 150 gallon drop tank, AN/ALQ-147(V)1 (store Station 6)
			163.0 (Aft)			

NOTES:

[1]All tests were conducted with Louvered Scarfed Shroud Suppressor installed.
[2]V_{s1}: Dual-engine power OFF stall airspeed for a specific aircraft configuration. Operator's manual recommended takeoff trim setting were used for the TO aircraft configuration.
[3]SLAR: Side Looking Airborne Radar.
[4]V_{yse}: Single-engine best rate of climb airspeed.
[5]Tests conducted at 1.7g.
[6]Tests conducted at 2.5g.

requirements for dual-engine unaccelerated, dual-engine accelerated and single-engine unaccelerated stalls is presented in figures 1, 2 and 3, respectively. The "MAXIMUM SPEED FOR ONSET FOR APPROACH ONLY" line shown on the figures equates to the aircraft approach configuration which is defined, for the purposes of this test, as gear down and flaps at 15 degrees or the TO configuration. The majority of the stall warning margins were within the military specification limits.

32. Under current training doctrine, pilots initiate a stall recovery at the first physical indication of a stall (aerodynamic buffet). The OV-1's unpredictable aerodynamic buffet can cause the pilot, in some cases, to stall the aircraft without any warning and at other times initiate stall recovery procedures at onset of aerodynamic buffet which may occur as much as 35 knots prior to the stall. This prevents the pilot from flying the aircraft at optimum slow airspeeds while maintaining a safe airspeed above stall. This is particularly true when performing accelerated maneuvers. The SFIC stall warning system has potential as a reliable artificial stall warning system providing pilot cues to recover the aircraft prior to an aerodynamic stall while permitting the aircraft to be safely maneuvered at speeds slower than the onset of aerodynamic buffet.

Dual-Engine Unaccelerated Stalls

33. A comparison of the dual-engine unaccelerated stall margins to the guidelines of the military specification are presented in figure 1. Sixty-five percent of the dual-engine stall margins were above the maximum military specification limit. These stall warning margins are not considered excessive and in many cases allow the pilot to fly the aircraft slower than the aerodynamic prestall buffet speed while maintaining sufficient airspeed to prevent a stall. A summary of dual-engine unaccelerated stall warning data is presented in tables 19 through 21, appendix E. The dual-engine unaccelerated stall warning margins provided by the stall warning system are satisfactory.

Dual-Engine Accelerated Stalls

34. A comparison of the accelerated stall data to the military specification guidelines is presented in figure 2. Although there were six points that fell outside the military specification limits, the stall warning system provided sufficient warning to correct the impending stall condition prior to the stall occurring. The aircraft could be flown at speeds well below the onset of aerodynamic buffet with sufficient speed margin remaining to prevent the stall from occurring when the stall warning system

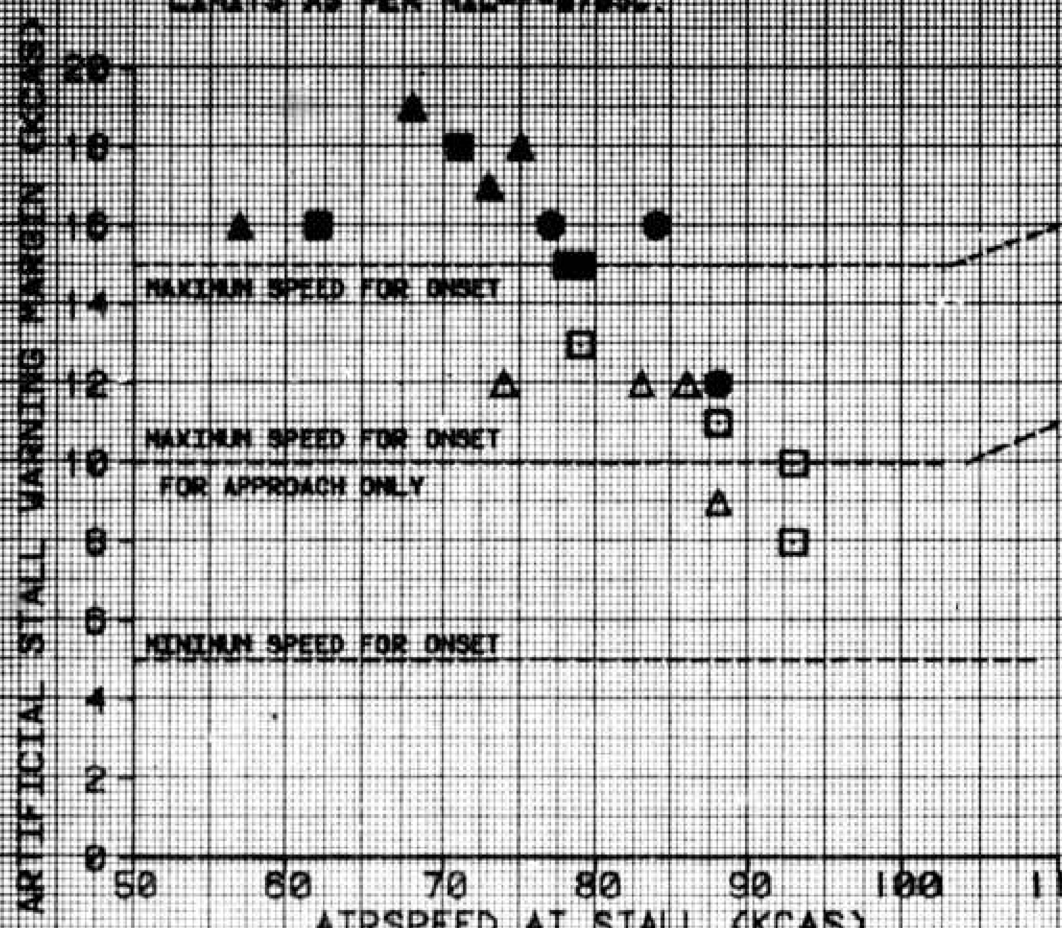
FIGURE 1
DUAL ENGINE UNACCELERATED STALL WARNING SUMMARY
OV-1D(C) USA S/N 62-5887

SYMBOL	AIRCRAFT CONFIGURATION	FLAP POSITION (DEGREES)	GEAR POSITION
⊡	TAKEOFF/APPROACH	15	DOWN
⊙	CRUISE	0	UP
△	LANDING	45	DOWN

NOTES: 1. TESTING CONDUCTED AT THE FOLLOWING CONDITIONS:

ENGINE START GROSS WEIGHT (lb)	STORES CONFIGURATION	ENGINE START CENTER OF GRAVITY (FS)
15,200	NO STORES	160.0 (MID)
17,500	TWO 150 GALLON DROP TANKS	160.5 (MID)
18,300	SIDE LOOKING AIRBORNE RADAR, TWO 150 GALLON DROP TANKS, AND AN/ALQ-147A(V)1 (STORE STATION 6)	157.0 (FWD) AND 163.0 (AFT)

2. POWER SETTINGS: FLIGHT IDLE AND MAXIMUM AVAILABLE.
3. SHADED SYMBOLS DENOTE MAXIMUM AVAILABLE POWER.
4. LOUVERED SCARFED SHROUD SUPPRESSOR INSTALLED.
5. DASHED LINES REPRESENT MILITARY SPECIFICATION LIMITS AS PER MIL-F-8785C.



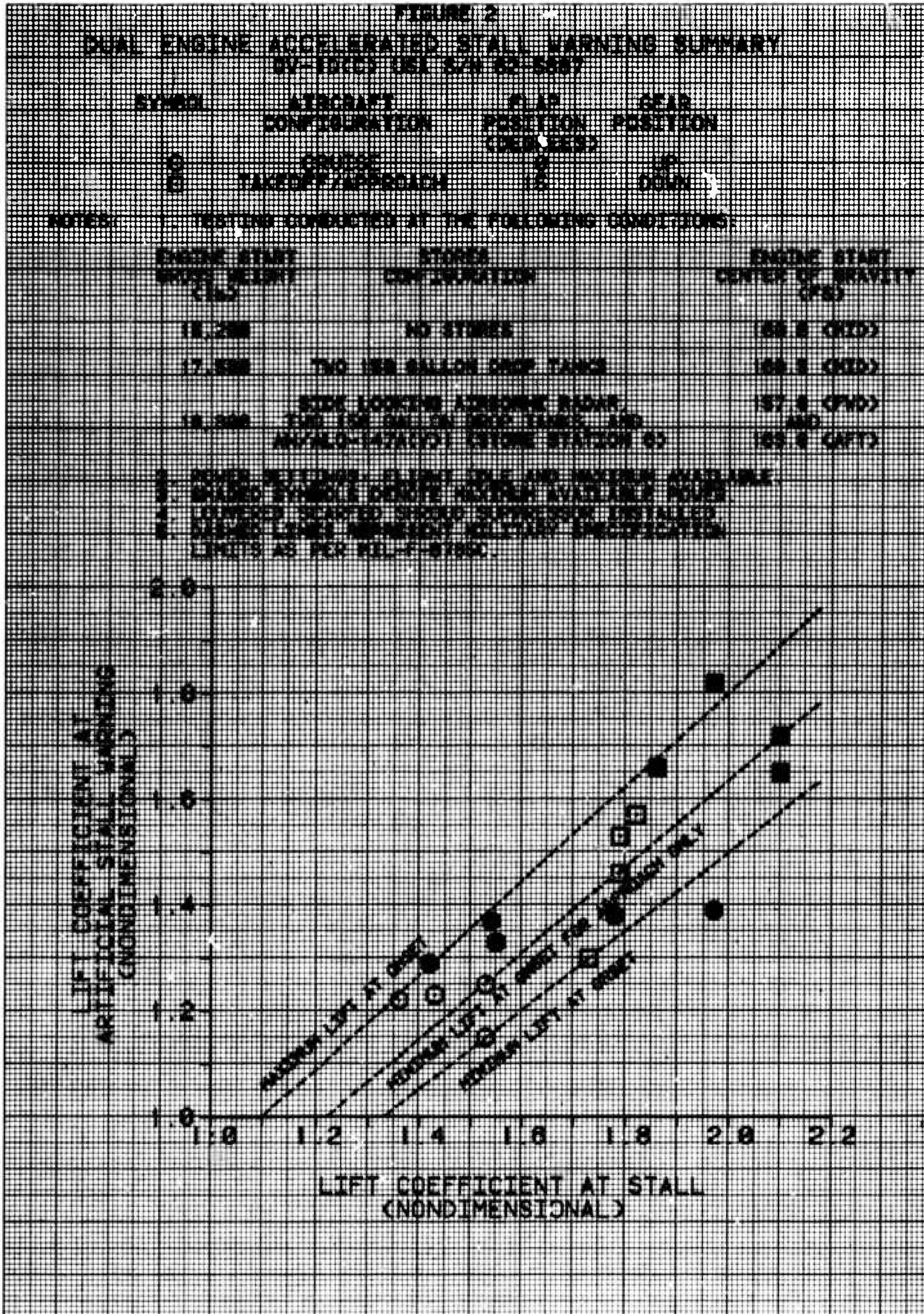


FIGURE 2
DUAL ENGINE ACCELERATED STALL WARNING SUMMARY
SYMBOL
AIRCRAFT CONFIGURATION
FLAP POSITION (DEGREES)
GEAR POSITION
TAKEOFF/APPROACH
DOWN
NOTES:
1. TESTING CONDUCTED AT THE FOLLOWING CONDITIONS:
ENGINE START GROSS WEIGHT
STORES CONFIGURATION
ENGINE START CENTER OF GRAVITY (FS)
NO STORES
TWO 150 GALLON DROP TANKS
SIDE LOOKING AIRBORNE RADAR,
AND
2. POWER SETTINGS: FLIGHT IDLE AND MAXIMUM AVAILABLE.
3. SHADED SYMBOLS DENOTE MAXIMUM AVAILABLE POWER
4. LOWERED SCARFED SHROUD SUPPRESSOR INSTALLED
5. DASHED LINES REPRESENT MILITARY SPECIFICATION LIMITS AS PER MIL-F-8785C.
LIFT COEFFICIENT AT ARTIFICIAL STALL WARNING (NONDIMENSIONAL)
2.0
1.8
1.6
1.4
1.2
1.0
MAXIMUM LIFT AT ONSET
MINIMUM LIFT AT ONSET FOR APPROACH ONLY
MINIMUM LIFT AT ONSET
1.0
1.2
1.4
1.6
1.8
2.0
2.2
LIFT COEFFICIENT AT STALL (NONDIMENSIONAL)

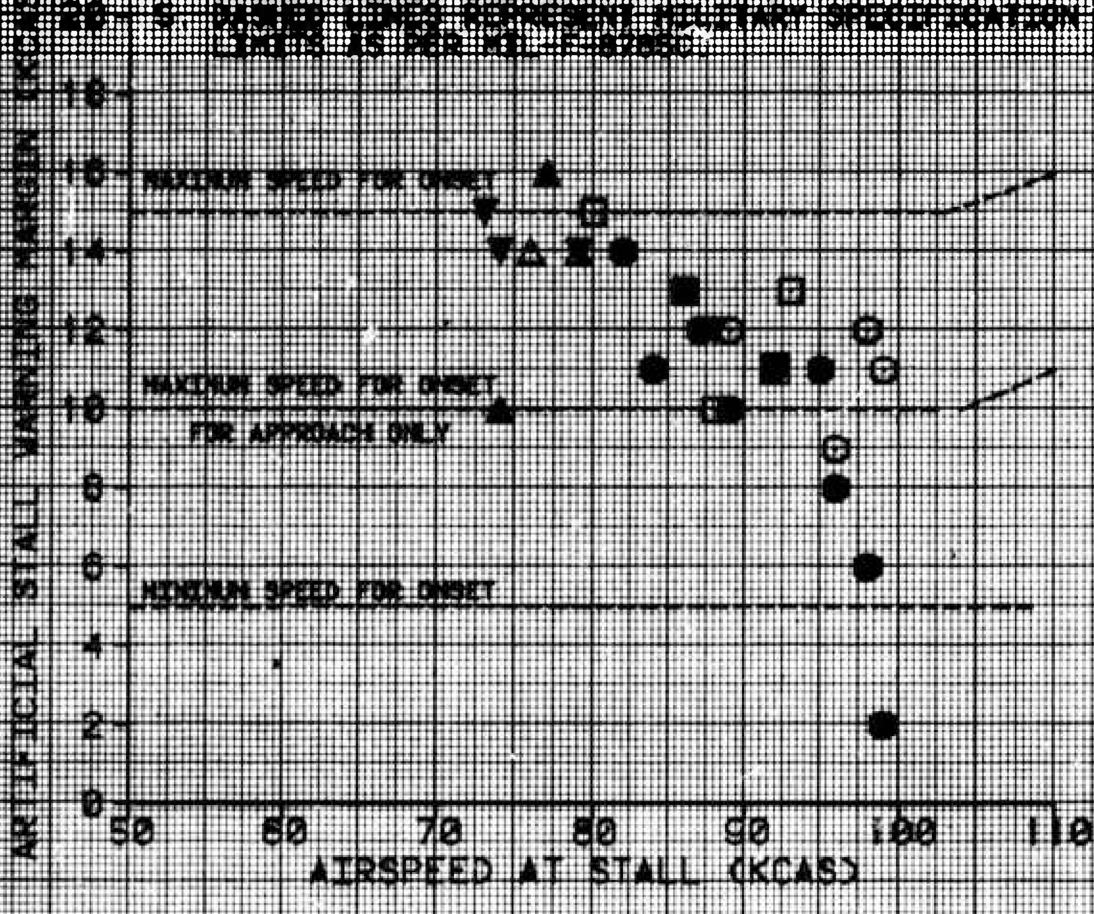
FIGURE 3
SINGLE ENGINE UNACCELERATED STALL WARNING SUMMARY
OV-1D(C) USA S/N 62-5867

SYMBOL	AIRCRAFT CONFIGURATION	FLAP POSITION (DEGREES)	GEAR POSITION
○	TAKEOFF/APPROACH	15	DOWN
□	CRUISE	0	UP
▽	GO-AROUND	15	UP
△	LANDING	45	DOWN

NOTES: 1. TESTING CONDUCTED AT THE FOLLOWING CONDITIONS:

ENGINE START GROSS WEIGHT (lb)	STORES CONFIGURATION	ENGINE START CENTER OF GRAVITY (FS)
15,200	NO STORES	160.0 (MID)
17,500	TWO 150 GALLON DROP TANKS	160.5 (MID)
18,900	SIDE LOOKING AIRBORNE RADAR, TWO 150 GALLON DROP TANKS, AND AN/ALQ-147A(V)1 (STORE STATION 8)	157.8 (FWD) AND 163.0 (AFT)

2. LOUVERED SCARFED SHROUD SUPPRESSOR INSTALLED
3. OPEN SYMBOLS DENOTE FLIGHT IDLE POWER ON OPERATING ENGINE
4. SHADED SYMBOLS DENOTE MAXIMUM AVAILABLE POWER ON OPERATING ENGINE
5. DASHED LINES REPRESENT MILITARY SPECIFICATION LIMITS AS PER MIL-F-83300.



activated. A summary of dual-engine accelerated stall warning data is presented in tables 26 and 27, appendix E. The accelerated stall warning margins provided by the SFIC stall warning system are satisfactory.

35. Incorporating the audio tone with the rudder pedal shaker enhanced the effectiveness of the stall warning system by providing stall warning cues through both the tactile and aural senses. The continuous 700 Hz audio stall warning tone activated simultaneously with the rudder shaker and remained ON until the airspeed margin was increased above the stall warning activation point. MIL STANDARD 411D requires an aural stall warning tone to be an interrupted 400 Hz audio signal varying from one cycle per second at activation to ten cycles per second at the point of stall. The SFIC stall warning audio tone did not meet the guidelines of MIL STANDARD 411D although it was satisfactory as an effective stall warning signal. A stall warning system consisting of a control shaker and an audio tone should be incorporated in the OV-1 aircraft.

Single-Engine Unaccelerated Stalls

36. A summary of the single-engine unaccelerated stall margin data is shown in figure 3. The majority of the single-engine margins were within the military specification guidelines with 19 percent above the maximum limit. These single-engine unaccelerated stall warning margins were satisfactory. One single-engine aircraft configuration was evaluated in which the SFIC stall warning margin was only 2 knots prior to the stall (3 knots below the military specification minimum limit). This occurred when performing a stall with the left engine simulated inoperative (power at idle) and the propeller unfeathered at the maximum rpm setting. This engine configuration could occur after an engine failure on short final during an approach with insufficient time to feather the propeller. This is a standard training procedure. Aerodynamic prestall buffet was unreliable as a pilot cue to impending stall as stated in paragraphs 9 and 21. A summary of single-engine unaccelerated stall warning data is presented in tables 22 through 25, appendix E. The insufficient artificial stall warning margin in the simulated left engine inoperative and propeller unfeathered configuration is a deficiency. Stall warning system modification and further testing is recommended to correct this deficiency and confirm adequate stall warning margins.

Operational Pilot Evaluations

General:

37. Two operational pilots, highly experienced in OV-1 tactics and flight crew training flew the test aircraft at a typical mission gross weight and center of gravity with the LSSS, SLAR, 150 gallon fuel tanks and AN/ALQ-147A(V)1 installed. Their qualitative assessments of the flight characteristics and evaluation of the SFIC stall warning system is presented in the following paragraphs.

First Operational Pilot's Comments:

38. "The LSSS configured OV-1D definitely needs a stall warning system. The stall warning provided by the Safe Flight Instrument Corporation system was good - the warning was not so early as to limit the aircraft performance nor so late that I did not have adequate time to prevent the stall after being alerted by the warning. I was cueing on the rudder shaker during the stalls performed during the first part of the flight because I was accustomed to hearing audio tones while using the radar warning equipment and flying against a threat. However, as the flight progressed, I began cueing on the stall warning audio tone. The rudder shaker complimented the audio tone and vice versa. I could feel the rudder shaker above the airframe buffet when performing accelerated maneuvers and the audio tone was very beneficial in this case. In the training environment, pilots are taught to recover at the first physical indication of a stall which is the airframe buffet. In the LSSS configured OV-1 during maneuvering flight, the airframe buffet may preceed the stall by as much as 40 knots. Pilots are trained to reduce the severity of the maneuver if this buffet occurs which is not necessary since the aircaft is actually not close to a stall. The stall warning system can act as the pilot's cue to reduce the severity of the maneuver, thereby allowing him to fly through the airframe buffet."

Second Operational Pilot's Comments:

39. "In my opinion the stall warning system provided excellent warning of impending stall throughout the normal flight envelope of the aircraft, especially during the conduct of maneuvers when the aircraft was configured for takeoff, approach and landing and during accelerated maneuvers. The system was especially helpful in determining imminent stall when the normal aerodynamic buffet was obscured by LSSS induced buffet. The system instilled confidence during maneuvers where I'd normally be riding on the

"edge of my seat" anticipating stalls. I flew more relaxed during these maneuvers knowing that I had an on-board system I could rely on to warn of imminent stall."

CONCLUSIONS

GENERAL

40. The following conclusions were reached based on the evaluation of the OV-1D stall characteristics:

a. Dual-engine unaccelerated and accelerated, and single-engine unaccelerated stall speeds were not significantly affected by installation of the LSSS (paras 13, 17 and 22).

b. Dual-engine flight idle power unaccelerated stall speed data are essentially in agreement with the operator's manual flight idle power stall speed chart (para 13).

c. Dual-engine flight idle power accelerated stall speed data are essentially in agreement with the operator's manual flight idle power stall speed chart (para 17).

d. There is no accurate maximum single-engine power stall performance data in the operator's manual (para 22).

e. Single-engine minimum control speed data in the operator's manual are inaccurate (para 24).

f. Dual-engine unaccelerated and accelerated stall warning margins provided by the SFIC stall warning system are satisfactory (paras 33 and 34).

g. The single-engine unaccelerated stall warning margins provided by the SFIC stall warning system were satisfactory except for one simulated engine out condition (para 36).

h. The minimum trim speed in the LSSS configuration was 1 to 6 KIAS higher than the non-LSSS configuration for dual-engine and 4 KIAS lower to 10 KIAS higher than the non-LSSS configuration for single-engine over the range of test cases and were satisfactory (para 25).

i. There is a high potential of exceeding the aircraft normal acceleration limitations when performing the evasive maneuvers outlined in the OV-1 Aircrew Training Manual during actual threat evasion (para 27).

j. The SFIC stall warning system has potential as a reliable artificial stall warning system providing pilot cues to recover the aircraft prior to an aerodynamic stall while permitting the aircraft to be safely maneuvered at speeds slower than the onset of aerodynamic buffet (para 32).

k. The SFIC stall warning system did not fully meet the guidelines of MIL STANDARD 411D and Military Specification, MIL-F-8785C (paras 33, 34, 35, and 36).

l. Two deficiencies and one shortcoming were identified during the conduct of these tests.

DEFICIENCIES

41. The inadequate prestall warning of the OV-1D without an artificial stall warning system (paras 9 and 15).

42. Insufficient artificial stall warning margin in the simulated left engine inoperative and propeller unfeathered configuration (para 36).

SHORTCOMING

43. Rudder pedal oscillations with the flaps down and power above 35 percent torque (para 11).

SPECIFICATION COMPLIANCE

44. The SFIC stall warning audio tone did not meet the guidelines of MIL STANDARD 411D although it was satisfactory as an effective stall warning signal (para 35).

45. The stall warning speed margins provided by the SFIC stall warning system did not fall within the guidelines of Military Specification, MIL-F-8785C for every configuration tested; however, the margins were satisfactory except for the simulated left engine out with the propeller unfeathered case (paras 33, 34 and 36).

RECOMMENDATIONS

46. Correct the deficiency identified in paragraph 41 as soon as possible. Correct the deficiency identified in paragraph 42 prior to final production configuration.

47. Correct the shortcoming in paragraph 43 as soon as practicable.

48. Update the single-engine minimum control speed data and include single-engine stall performance data in the operator's manual (paras 24 and 22).

49. Incorporate a stall warning system consisting of a control shaker and an audio tone in the OV-1 aircraft (para 35).

50. Review the aircraft normal acceleration limitations to ascertain if the symmetric and asymmetric g envelope can be substantially increased permitting higher normal acceleration limits for actual threat evasion (para 27).

51. Modify the stall warning system and conduct further testing to correct the insufficient stall warning margin in the simulated left engine inoperative and propeller unfeathered configuration (para 36).

52. Recommend the following NOTE be incorporated in the operator's manual (para 6):

NOTE

> Unpredictable and inconsistent aerodynamic stall warning (prestall) buffet speed margins will be encountered with different aircraft configurations and power settings in both unaccelerated and accelerated flight conditions.

53. A discussion of aircraft prestall and stall characteristics in the LSSS configuration should be included in the operator's manual with the following NOTE (para 6):

NOTE

> In LSSS configured aircraft, airframe prestall buffet accompanied with left wing drop which requires approximately 1 to 1.5 inches of lateral stick displacement to maintain wings level may occur well above stall.

APPENDIX A. REFERENCES

1. Letter, AVSCOM, DRSAV-ED, 8 June 1984, with revision 1 10 July 1984, subject: Evaluation of OV-1D Stall Warning Characteristics.

2. Field Circular, FC 1-217, Aircrew Training Manual, *Surveillance Airplane, OV-1,* 30 December 1984.

3. Technical Manual, TM 55-1510-213-10, Operator's Manual, OV-1D/RV-1D Aircraft, 4 August 1978, through change 10, 25 October 1985.

4. Letter, USAAEFA, SAVTE-TA, 8 August 1984, subject: Test Plan, Evaluation of OV-1D Stall Warning Characteristics, USAAEFA Project No. 84-13.

5. Letter, AVSCOM, AMSAV-E, 30 August 1984, subject: Airworthiness Release, OV-1D S/N 62-5867, Evaluation of Stall Warning Characteristics, USAAEFA Project No. 84-13.

6. Military Specification, MIL-F-8785C, Flying Qualities of Piloted Airplanes, 5 November 1980.

7. Military Standard, MIL STANDARD 411D, *Aircrew Station Signals,* 30 June 1970.

8. Flight Test Manual, Naval Air Test Center, FTM No. 103, *Fixed Wing Stability and Control,* 1 January 1975.

9. Flight Test Manual, Naval Air Test Center, FTM No. 104, *Fixed Wing Performance,* July 1977.

10. Pilot's Guide, Safe Flight Instrument Corporation, R-2145, *Prestall Warning System Grumman OV-1D/RV-1D (Mohawk),* 20 August 1985.

APPENDIX B. DESCRIPTION

1. The test aircraft was an OV-1D(C) US Army Serial Number 62-5867 (photos 1 through 9). The OV-1 is a two-place twin turboprop aircraft with a midwing design, triple vertical stabilizers and tricycle landing gear. It incorporates mechanically operated rudders and outboard ailerons and hydraulically operated flaps and inboard ailerons. The inboard ailerons operate with lateral control stick movement between the nominal range of 24 degrees up and 25 degrees down with the flaps at the 15 or 45 degree positions. The two Lycoming gas turbine T53-L-701 engines are rated at 1400 shaft horsepower at standard day sea level conditions and incorporate Hamilton Standard three-bladed, constant speed, full-feathering, reversible-pitch propellers. The OV-1D is designed to carry external wing stores at six locations. The wing store locations are numbered one through six starting with the first wing store location outboard on the left wing. Additionally, a side-looking airborne radar (SLAR) pod can be attached to the forward right side of the fuselage. The aircraft was tested without external stores; with two 150 gallon Sargent Fletcher fuel drop tanks on store stations 3 and 4; and with the SLAR pod (AN/APS-94F), two 150 gallon Sargent Fletcher fuel drop tanks on store stations 3 and 4, and the infrared countermeasures set AN/ALQ-147A(V)1 on store station 6. The aircraft engine nacelles incorporate either the standard engine exhaust stacks (Kit A) or the Louvered Scarfed Shroud Suppressor (LSSS) (Kit B). The stall characteristics were evaluated in both configurations. A detailed description of the OV-1D and its mission equipment is contained in the operator's manual, OV-1D/RV-1D Aircraft, TM 55-1510-213-10 (ref 3, app A).

2. A Safe Flight Instrument Corporation (SFIC) stall warning system was installed in the test OV-1D(C) aircraft throughout the stall characteristics evaluation. The final stall warning system configuration consisted of the following components: a lift transducer, flap position transmitter, lift computer, rudder pedal shaker, stall warning tone generator, and a weight on wheels switch. The lift transducer is an electomechanical device consisting of a moveable vane and mounting plate which will incorporate integral anti-icing heaters in the production configuration. The anti-icing heaters will be activated through the aircraft pitot heat switch. The lift transducer was mounted on the right wing (photos 10 and 11). The spanwise location of the center of the lift transducer vane was located at right wing station 273.8. This was 8 inches inboard of the most outboard right wing rib (wing station 281.8). The chordwise location of the center of the lift transducer vane was on the lower surface of the wing leading edge 5.375 inches forward of the forward edge of the skin line on the bottom of the wing (where the wing skin and deice boot join). This corresponds to 6.531 inches forward of the forward edge of the skin line on the top of the wing

(where the wing skin and deice boot join). These dimensions were measured along the surface of the wing deice boot. During flight, the vane position is determined by airflow stagnation point location on the wing and is a function of local airflow which varies with changes in angle of attack of the wing. The lift transducer provides an electrical signal to the lift computer which is proportional to the lift coefficient ratio, $C_L/C_{L_{max}}$. The flap transmitter is an electromechanical device which supplies flap positition information to the lift computer. In the test aircraft, a three-position flap switch was used to provide flap position information to the lift computer; however, in the production configuration the flap position transmitter will be connected to the flap system and automatically supply flap position information to the lift computer. The preproduction stall warning system incorporated an AIR/GND switch which deactivated the rudder shaker and audio warning tone when in the GND position. In the production configuration, this switch will be located on the landing gear and automatically disable stall warning and supply low heat to the anti-icing heaters of the lift transducer, assuming the aircraft pitot heat switch is ON, when the aircraft is on the ground. The lift transducer and flap position transmitter supply signals to the lift computer which activate the rudder shaker and audio tone at a predetermined margin prior to the aircraft reaching an aerodynamic stall. The rudder pedal shaker was mounted on the pilot's left rudder pedal (photo 12) and is actuated by a signal from the lift computer providing tactile prestall warning to the pilot. The rudder shaker is an electric powered drive motor with a 0.3463 pound shaft mass imbalance which rotates at approximately 25 rpm. The stall warning tone generator is activated by a signal from the lift computer and provides a 700 Hertz (Hz) audio tone at +12 decible miliwatts to the pilot's and copilot's intercom system. The tone generator will provide a 400 Hz tone in the production configuration. It activates simultaneously with the rudder shaker to provide an audio stall warning signal. The tone volume can be neither decreased nor disabled by the flight crew. The stall warning system incorporates a self-test switch which allows the pilot to check the system on the ground or in flight. When the aircraft is on the ground, a solenoid in the lift transducer actuates to push the vane forward and simulate a stall condition activating the rudder shaker and stall warning tone. Actuating the self-test switch in flight introduces an electrical test signal simulating forward movement of the lift transducer vane causing rudder shaker and stall warning tone activation. In the production configuration the solenoid will be inhibited through the stall warning system weight on wheels switch when the aircraft is in flight. A more detailed description of the SFIC stall warning system can be found in the SFIC Prestall Warning System Grumman OV-1D/RV-1D (Mohawk) Pilot's Guide (ref 10, app A).

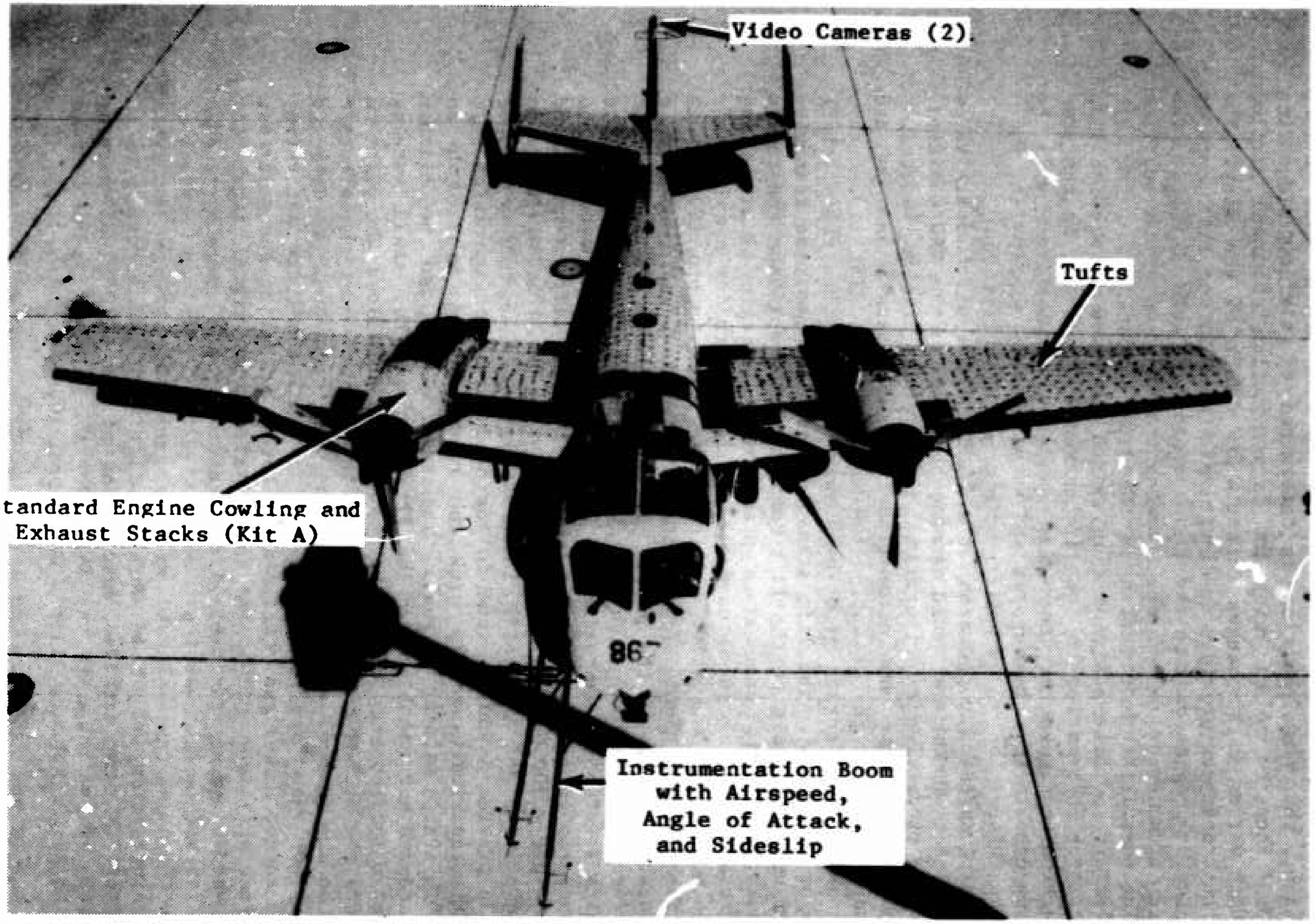


Photo 1. OV-1D(C) Unsuppressed without Wing Stores

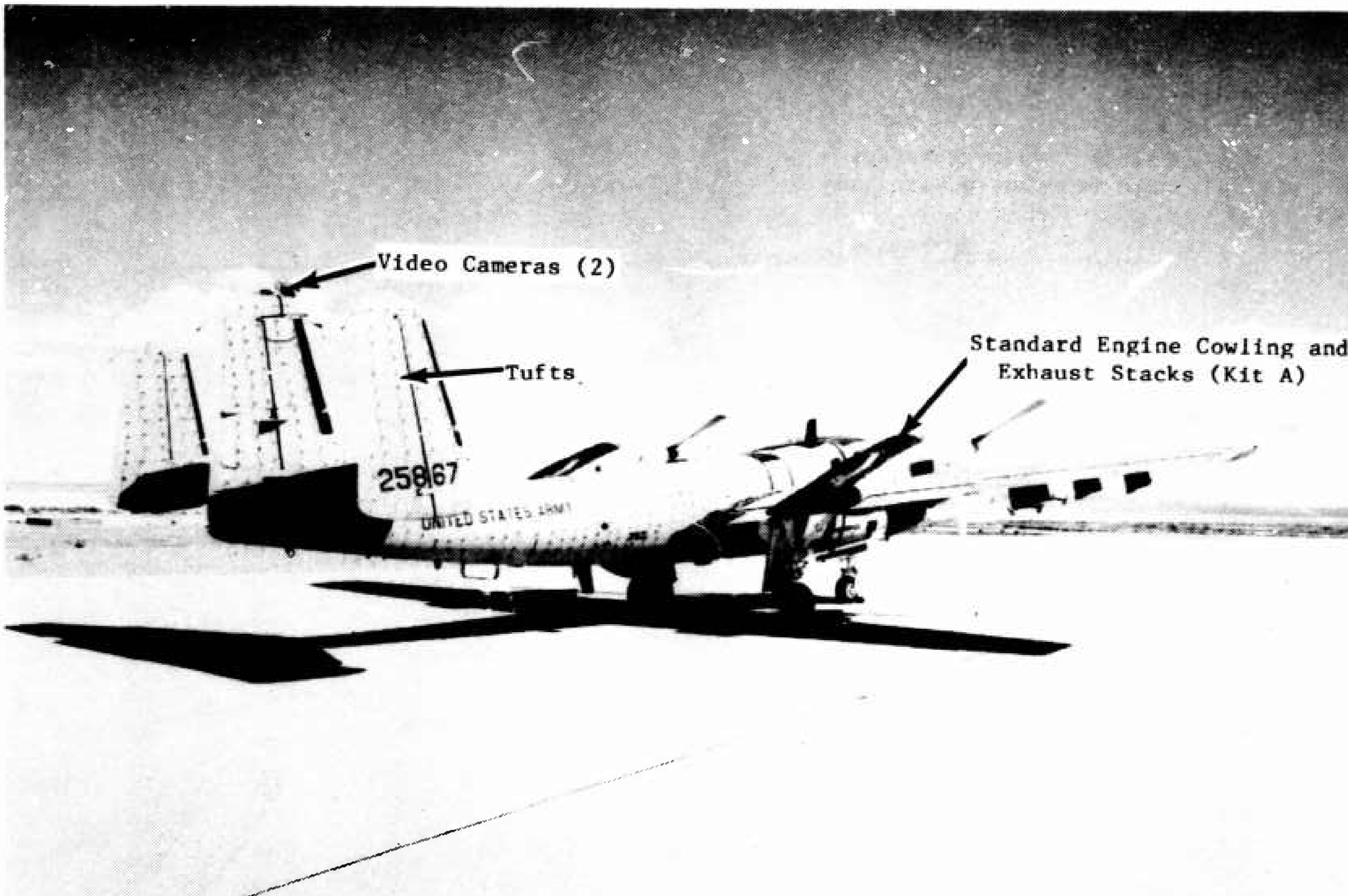


Photo 2. OV-1D(C) Unsuppressed without Wing Stores

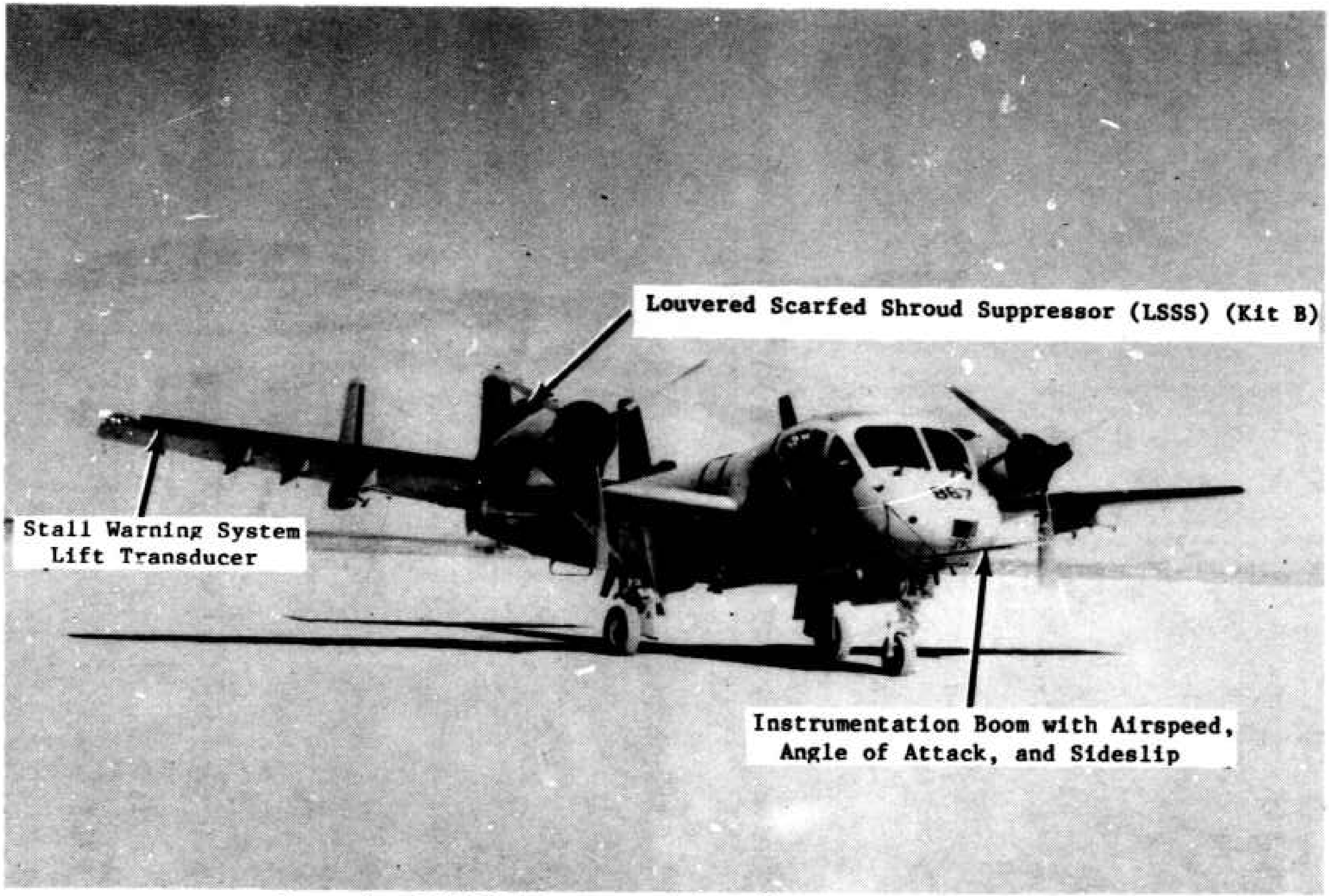


Photo 3. OV-1D(C) Suppressed (LSSS) without Wing Stores

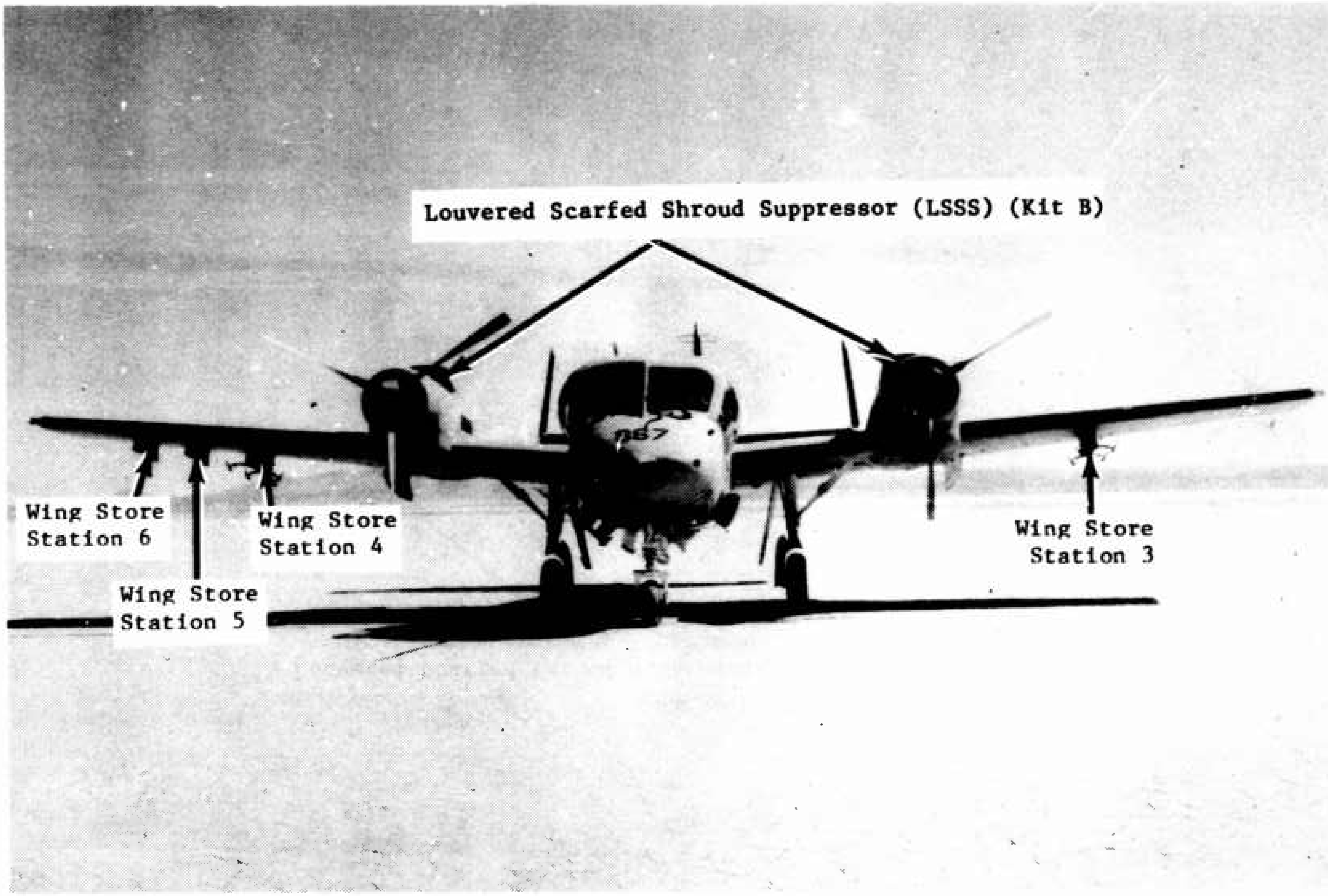


Photo 4. OV-1D(C) Suppressed (LSSS) without Wing Stores

Photo 5. OV-1D(C) Suppressed (LSSS) without Wing Stores

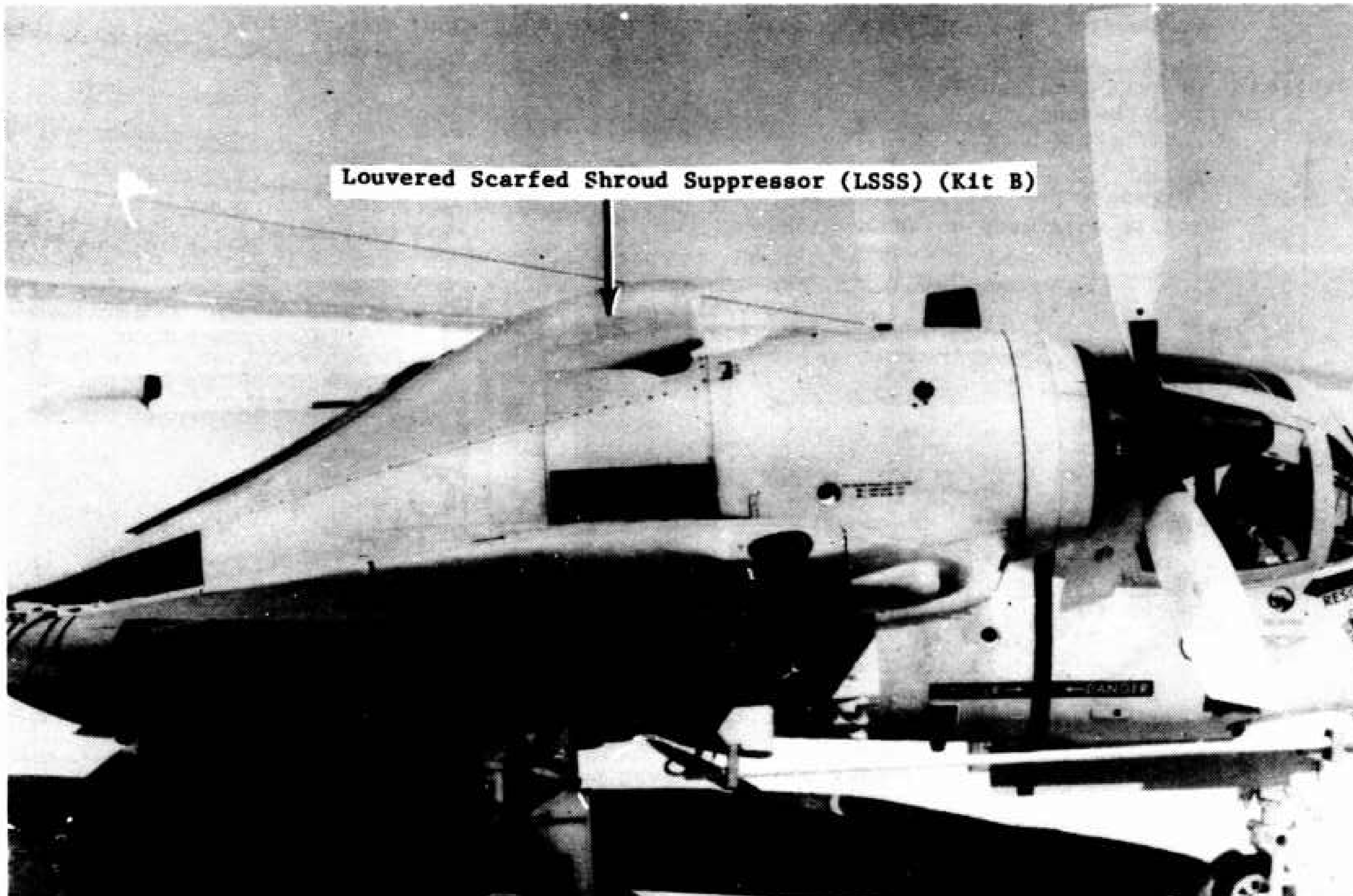


Photo 6. OV-1D(C) Suppressed (LSSS) without Wing Stores

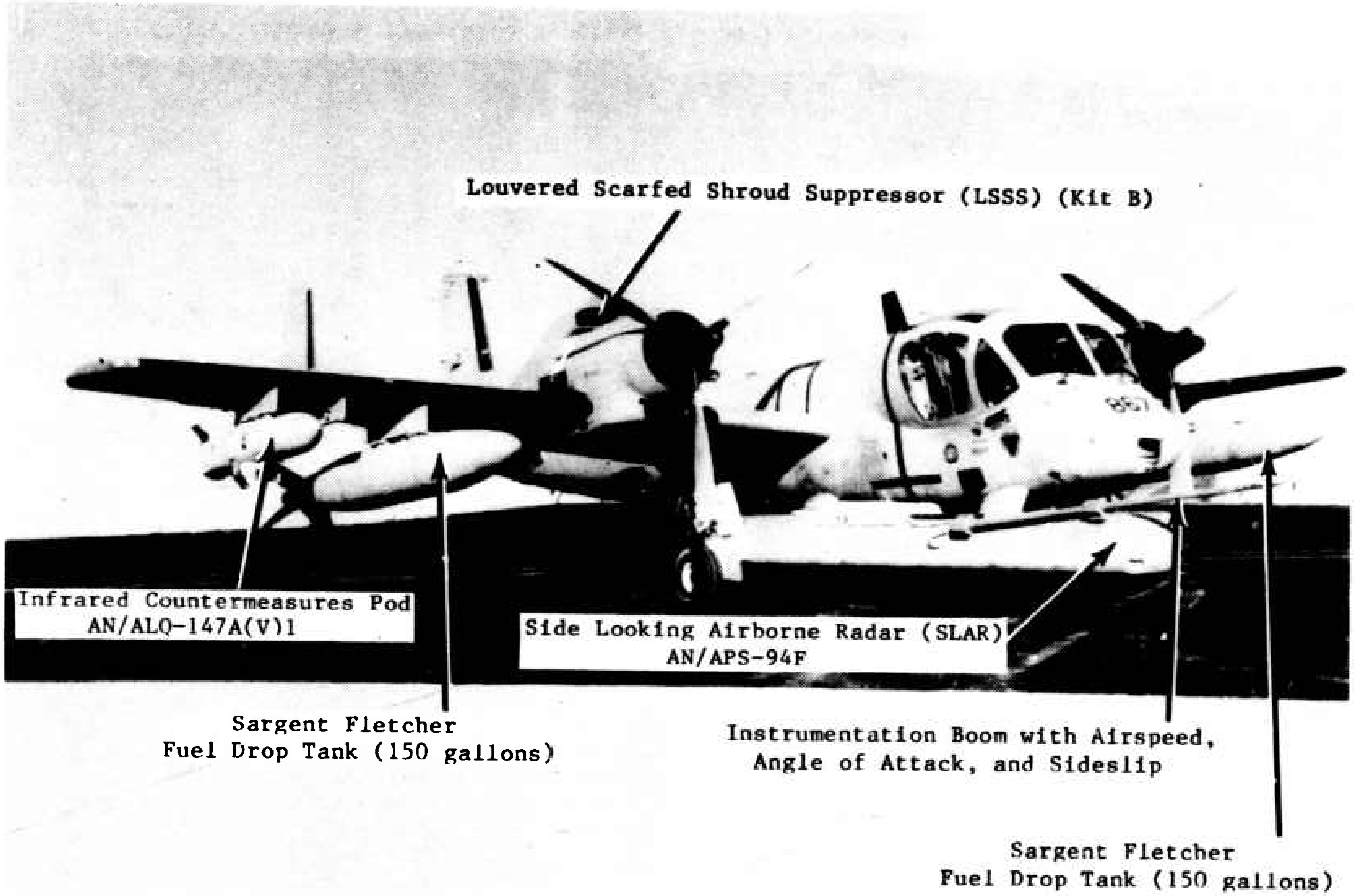


Photo 7. OV-1D(C) Suppressed (LSSS) with Externl Mission Equipment

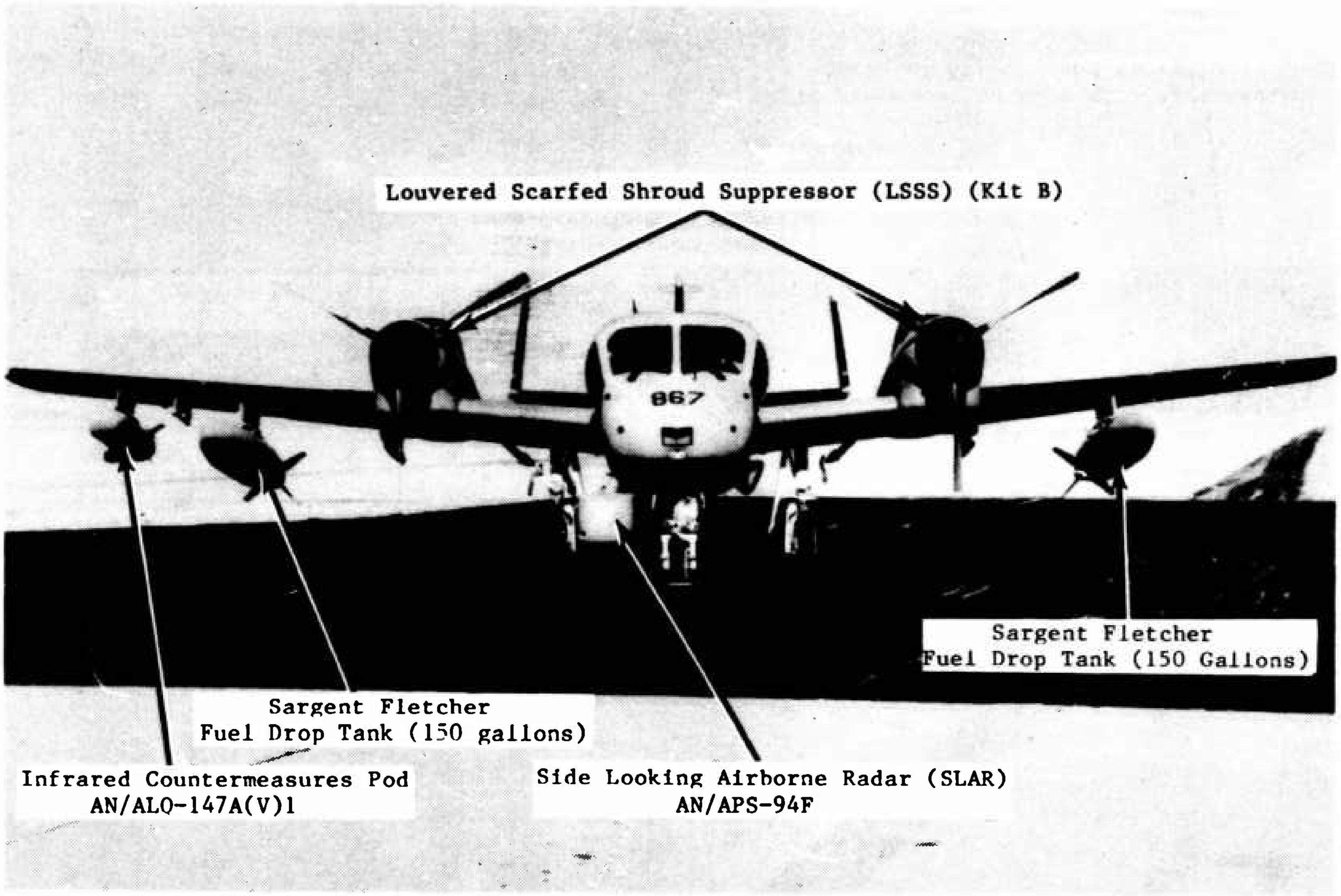


Photo 8. OV-1D(C) Suppressed (LSSS) with External Mission Equipment

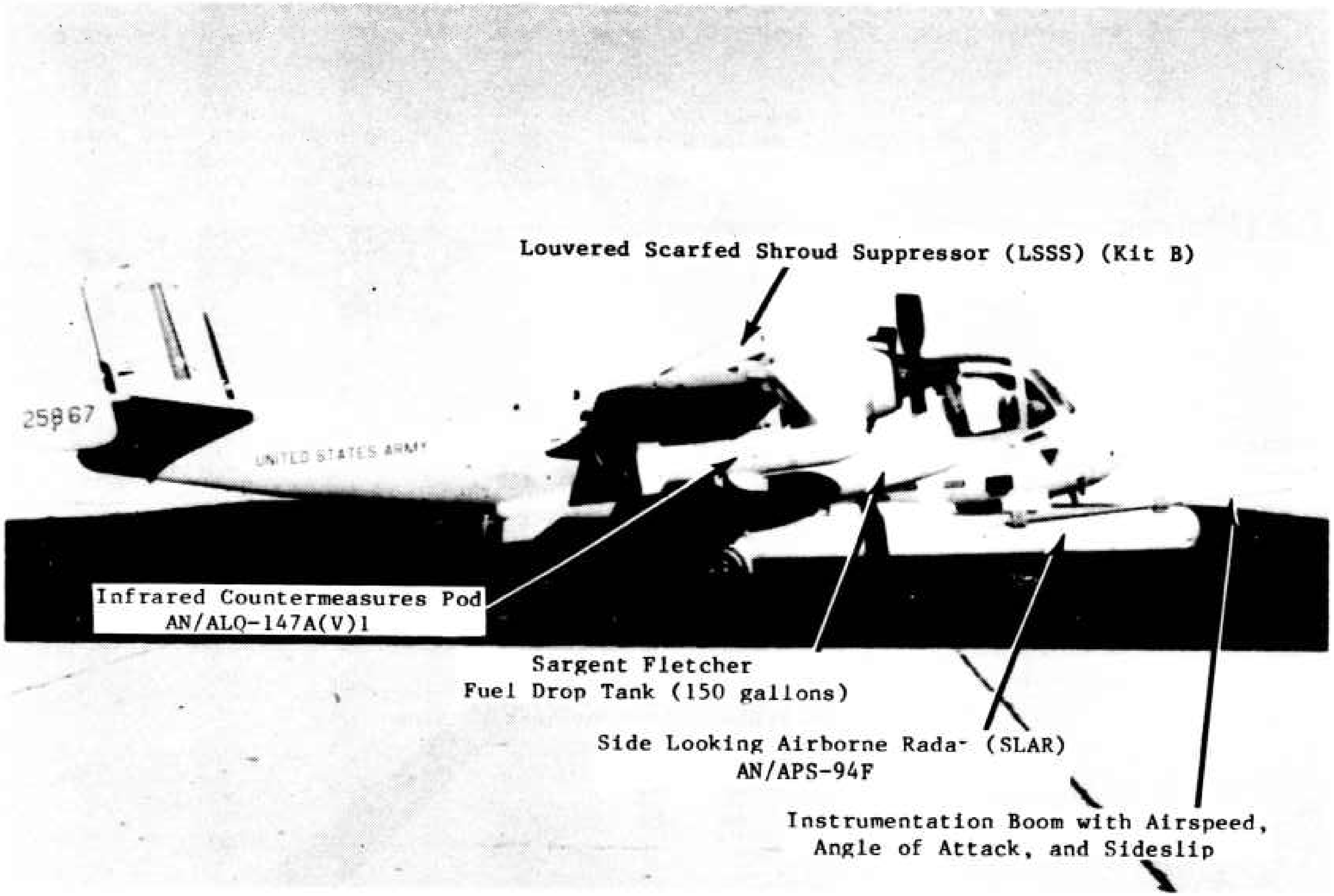


Photo 9. OV-1D(C) Suppressed (LSSS) with External Mission Equipment

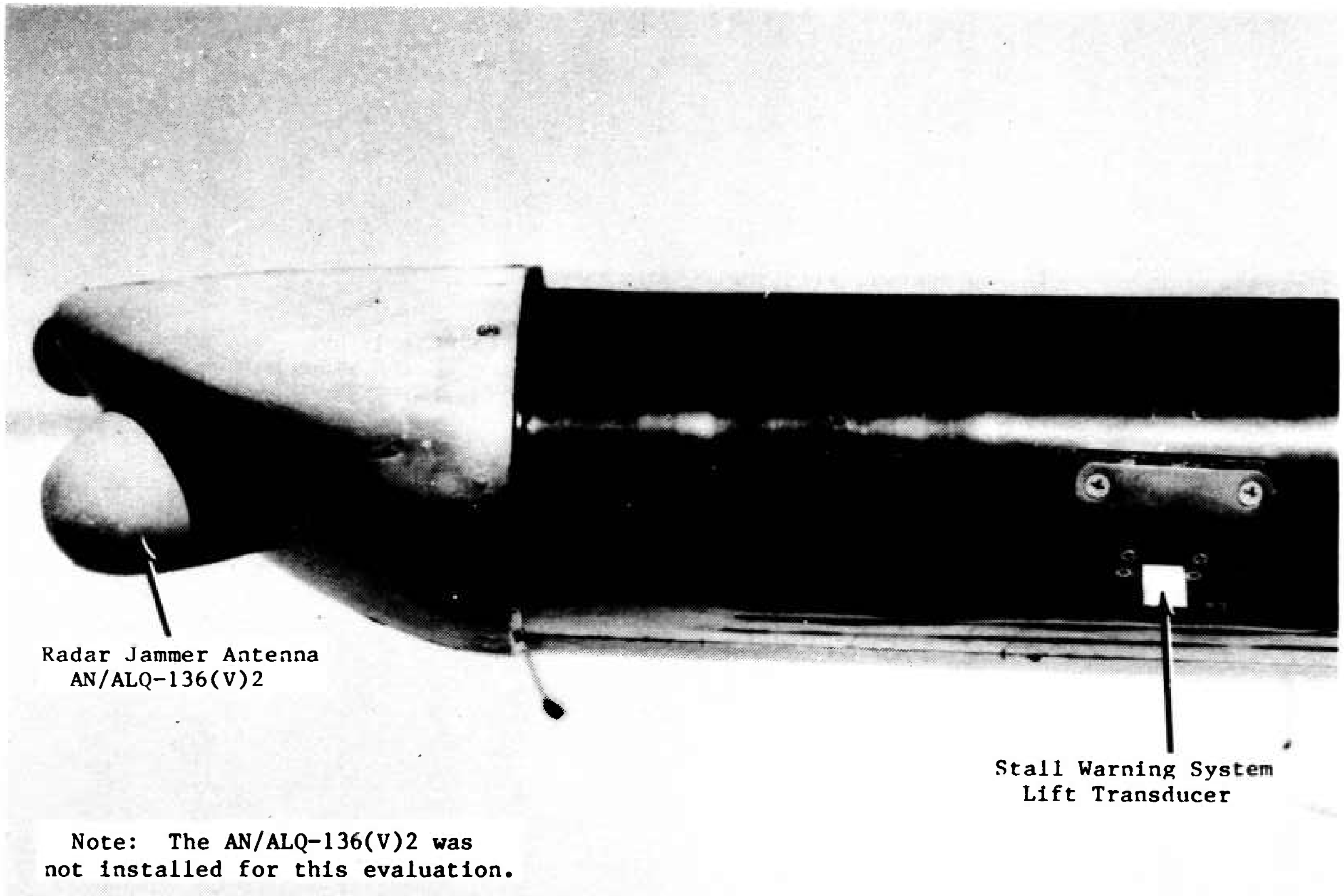


Photo 10. OV-1D(C) Right Wing Tip (Front View)

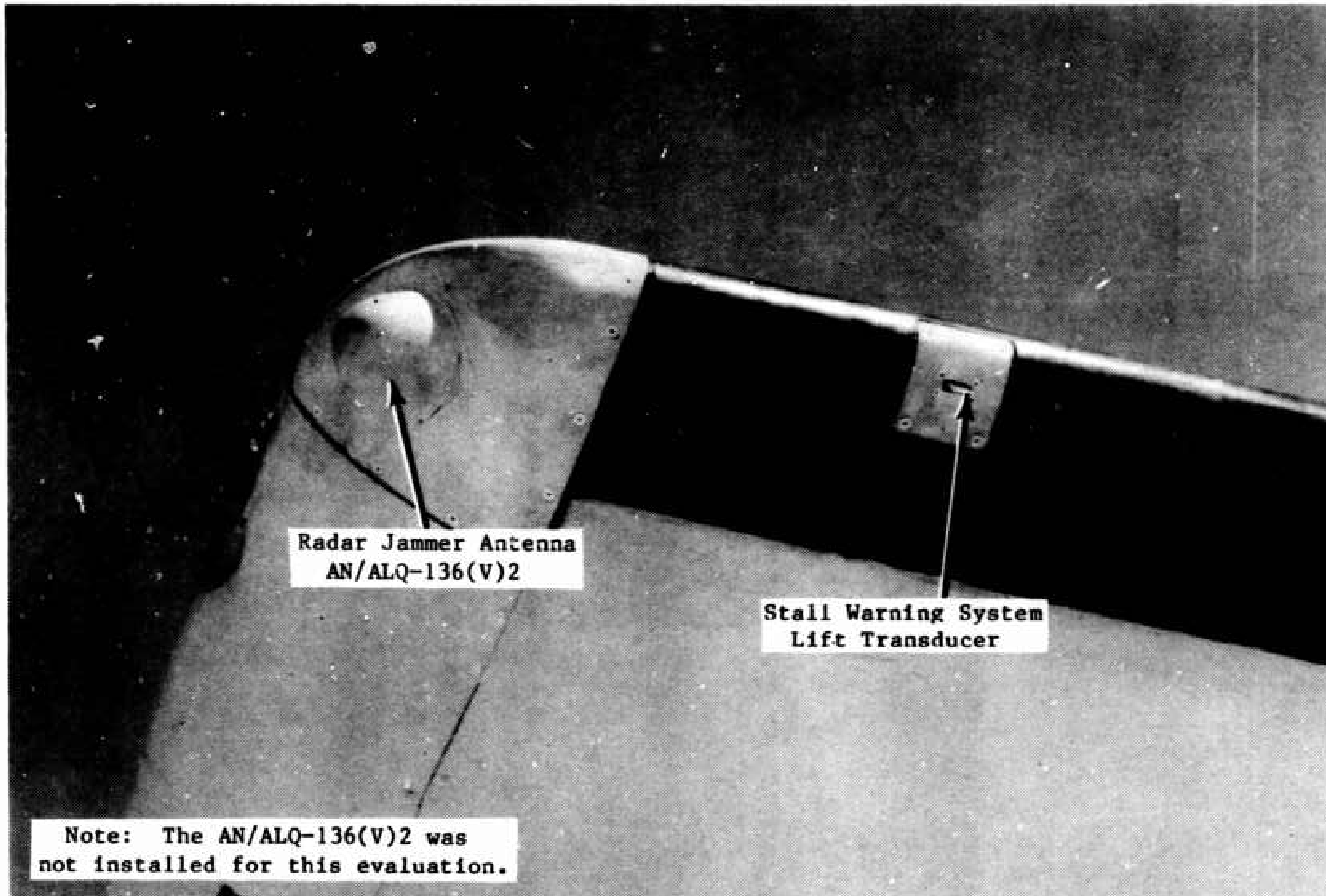


Photo 11. OV-1D(C) Right Wing Tip (Bottom View)

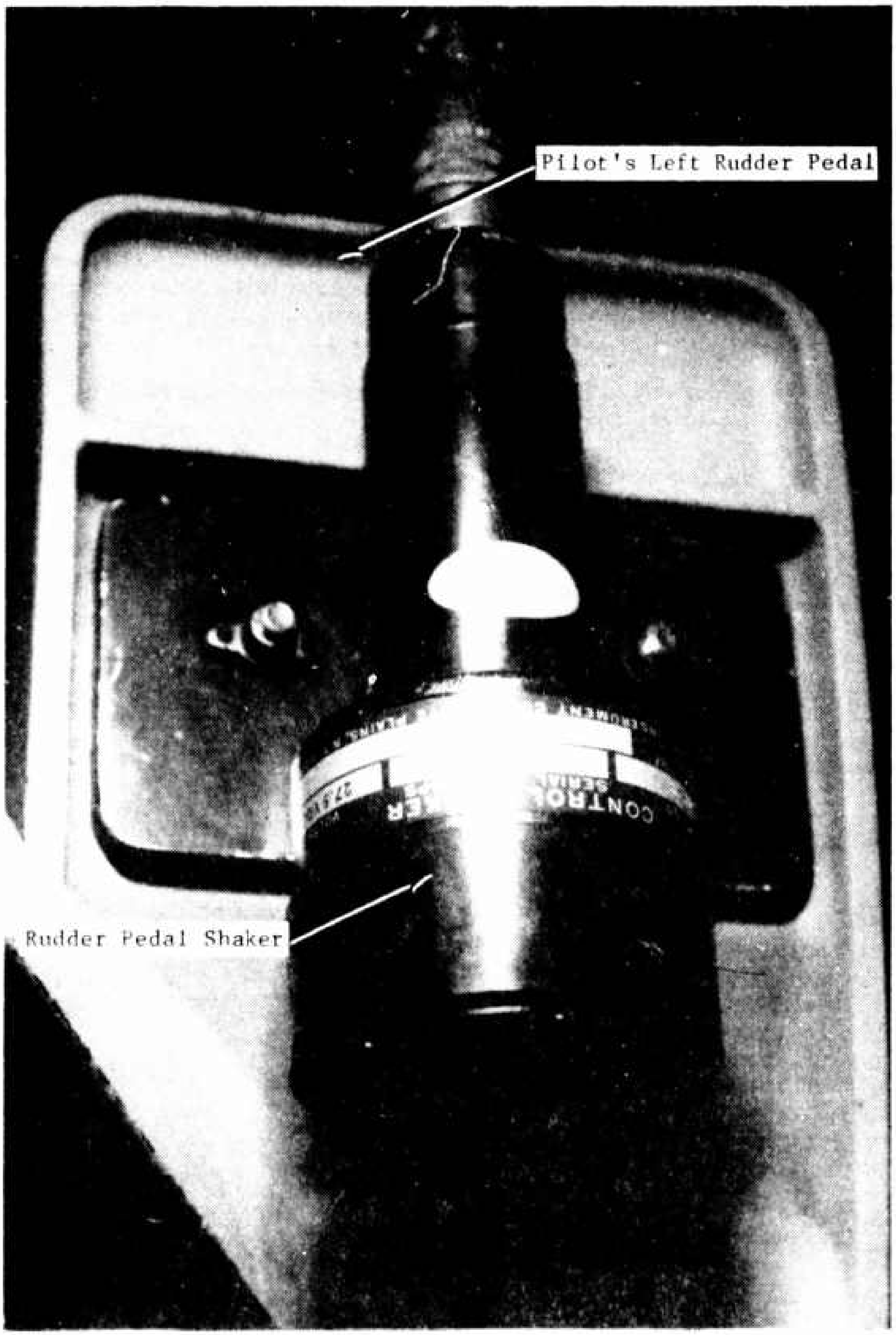


Photo 12. Rudder Pedal Shaker (View of Pilot's Left Pedal Looking Aft)

APPENDIX C. INSTRUMENTATION

1. Flight test data were recorded on magnetic tape onboard the test aircraft and via telemetry to the Real-Time Data Acquisition and Processing System (RDAPS) facility. An instrumented boom was installed to provide pitot and static pressure, sideslip, and angle of attack data (photos 1, 3, 7 and 9, app B). The boom was attached to the Side Looking Airborne Radar (SLAR) pod attachment points for flights which did not include the SLAR pod as part of the aircraft external configuration and attached to the SLAR pod for flights that included the SLAR pod. The aircraft wings, engine nacelles, and empennage were tufted for air flow visualization (photos 1 and 2). Two video cameras mounted on top of the center vertical stabilizer were used to record wing tuft movement throughout the stall characteristics evaluation (photos 1 and 2).

2. The following test instrumentation was used in addition to the standard aircraft instruments:

Cockpit panel

Engine fuel flow (left and right)
Engine fuel totalizer (left and right)
Airspeed (ship and boom)
Altitude (ship and boom)
Ambient air temperature
Angle of attack (boom system)
Angle of attack (Safe Flight system)
Angle of sideslip (boom system)
Normal acceleration
Time code

Magnetic tape

Airspeed (ship and boom)
Altitude (ship)
Ambient air temperature
Longitudinal control position
Lateral control position
Directional control position
Angle of attack (boom system)
Angle of attack (Safe Flight system)
Angle of sideslip (boom system)
Pitch attitude
Roll attitude
Heading
Pitch rate
Roll rate
Yaw rate

Center of gravity normal acceleration
Center of gravity longitudinal acceleration
Center of gravity vertical acceleration
Pilot's seat lateral acceleration
Pilot's seat longitudinal acceleration
Pilot's seat vertical acceleration
Pilot's longitudinal stick acceleration
Pilot's right directional pedal acceleration
Pilot's right directional pedal force
Exhaust gas temperature (left and right)
Fuel flow (left and right)
Fuel totalizers (left and right)
Propeller speed (left and right)
Gas generator speed (left and right)
Engine torque (left and right)
Throttle position (left and right)
Time

APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

GENERAL

1. This appendix contains a description of the test techniques used for evaluating the dual and single-engine unaccelerated stall characteristics, dual-engine accelerated stall characteristics, and single-engine minimum control airspeed (V_{mc}). A brief description of the evasive maneuvers is also included. Additionally, some of the data reduction techniques and analysis methods used to evaluate the OV-1D aircraft are presented.

DUAL AND SINGLE-ENGINE UNACCELERATED STALLS

2. Dual and single-engine unaccelerated stalls were performed by trimming the aircraft at a specified airspeed or recommended trim settings at a power, gear, and flap configuration and decelerating the aircraft at one knot per second or less until the stall occurred. Aircraft stall was identified from the time history data as the point of maximum lift coefficient. Indicated stall airspeed was defined as the ship's indicated airspeed at stall. Calibrated stall airspeed was defined as the boom calibrated airspeed at stall, except in the modified Safe Flight Instrument Corporation (SFIC) stall warning system evaluation where it was defined as SHIP's calibrated airspeed. The operator's manual recommended elevator, rudder, and aileron trim settings were used for dual-engine stalls conducted in the takeoff (TO) configuration. The trim settings used for dual-engine unaccelerated stalls in the cruise (CR), go-around (GA), and landing (L) configuration were those required for minimum control forces using power required for coordinated level flight at 1.2 times the estimated dual-engine power OFF stall speed (V_{s1}). Single-engine stalls were performed with the left engine shutdown and propeller feathered except for the single-engine stalls simulating an engine failure on final approach for landing where the propeller would not be feathered. For this scenario, the simulated failed engine power lever was in the flight idle power position with the propeller lever at maximum rpm. Trim settings for single-engine stalls were those required for minimum control forces using maximum power on the operating engine at the single-engine best rate of climb airspeed (V_{yse}) recommended in the operator's manual.

DUAL-ENGINE ACCELERATED STALLS

3. Accelerated stalls were performed using left windup turns by maintaining a constant airspeed and slowly increasing the normal load factor by increasing the bank angle and aft stick force.

Trim settings for accelerated stalls were those required for minimum control forces using power required for coordinated level flight at 1.4 V_{s1}.

SINGLE-ENGINE MINIMUM CONTROL AIRSPEED

4. Static and dynamic V_{mc} tests were conducted with the critical engine (left engine) inoperative or simulated inoperative. Static V_{mc} was defined as the minimum airspeed at which a straight flight path could be maintained using full directional and/or full lateral control and up to a 5 degree bank angle toward the operating engine which was producing maximum available power. Trim setting used for static V_{mc} determination were those recommended by the operator's manual in the TO configuration and those required for minimum control forces in the CR, GA, and L configurations at the minimum controllable airspeed. Dynamic V_{mc} was defined, from a condition using maximum power available on both engines, as the minimum airspeed at which aircraft control could be regained in order to maintain a straight flight path with less than 5 degrees bank angle after simulating a failure of the left engine. The simulated engine failure was accomplished by rapidly reducing the left engine power lever to flight idle power while in a stabilized flight condition and delaying any flight control movements for one second or until a 20 degree bank angle or a heading change of 20 degrees was reached, whichever occurred first. Dynamic V_{mc} determination in the TO configuration included reducing the propeller rpm to minimum after the throttle reduction to flight idle power, simulating activation of the auto-feather system after engine failure. Dynamic V_{mc} determination in the CR, GA, and L configurations was performed by rapidly reducing the power lever to flight idle on the left engine without simulating a feathered propeller. Trim settings used for dynamic V_{mc} determination were those recommended by the operator's manual in the TO configuration and those required for minimum control forces using dual-engine power required for coordinated level flight at 1.2 V_{s1} in the CR, GA and L configurations.

EVASIVE MANEUVERS

5. The evasive maneuvers described in Field Circular, FC 1-217, Aircrew Training Manual for the OV-1 Surveillance Airplane (ref 2, app A) were qualitatively evaluated during the stall characteristics tests at the conditions shown in table 2. The execution of these maneuvers was modified to include retaining the wing stores throughout the maneuver and descending not lower than a predetermined safe altitude (5000 feet above ground level (AGL)) rather than an extremely low altitude for the maneuvers which specified

utilizing a rapid descent to achieve a minimum altitude for terrain masking. The maneuvers were entered from approximately 10,000 feet AGL, wings level, cruise flight at 60 to 65 percent torque and 155 to 160 knots indicted airspeed (KIAS). Cruise power was maintained throughout the maneuver unless required to be reduced to avoid going beyond the never exceed airspeed (V_{NE}). The aircraft was configured with the Louvered Scarfed Shroud Suppressor (LSSS), Side Looking Airborne Radar (SLAR) pod, infrared countermeasures pod (AN/ALQ-147A(V)1), and two 150 gallon fuel drop tanks. The takeoff gross weight was 17,900 pounds and the longitudinal center of gravity at 159.4 inches. A brief description of the evasive maneuvers performed during this evaluation follows.

a. High Speed Dive

Rapid 90 degree angle of bank (AOB) and 90 degree heading change while simultaneously pushing over to a 30 to 45 degree dive angle descending rapidly to 5000 feet AGL and rolling to wings level.

b. High Speed Dive with Orthogonal Break

Rapid 90 degree AOB and 90 degree heading change while simultaneously pushing over to a 30 to 45 dive angle to descending rapidly to 6000 feet AGL, rolling wings level, followed by a wings level symmetric pull-up to approximately 30 degrees nose up attitude with a wings loaded aileron roll (below 250 KIAS) to wings level.

c. Modified Split "S"

Rapid 120 degree AOB and at least a 90 degree heading change while simultaneously pulling to a 30 to 45 degree dive angle descending rapidly to 5000 feet AGL.

d. Modified Split "S" with Orthogonal Break

Rapid 120 degree AOB and at least a 90 degree heading change while simultaneously pulling to a 30 to 45 degree dive angle to 5500 feet AGL followed by a wings level symmetric pull-up to 30 degrees nose up attitude with a wings loaded aileron roll to wings level.

e. Split "S"

Rapid 180 degree AOB to inverted flight, aft stick through vertical (nose down) to a 30 to 45 degree dive angle, reducing power as necessary to avoid exceeding V_{NE}, descending rapidly to 5000 feet AGL and recovering to wings level.

f. Jink

Alternating left and right steep turns (60 to 90 degrees AOB) of 5 seconds duration each.

g. 90 Degree Turn with Descent

Rapid bank to 90 degrees simultaneously lowering the nose, 90 degree heading change and descend at least 1000 feet to wings level.

h. Diving Spiral

Rapid bank to 90 degrees simultaneously lowering the nose. After 90 degree heading change reduce back pressure to maintain the heading and perform an unloaded aileron roll (below 250 KIAS) recovering to wings level.

DATA ANALYSIS METHODS

Airspeed Determination

6. Instrument corrected airspeeds (Vic) using the PCM system were obtained through the equation:

$$V_{ic} = a_o \; [\; 5 \; [\; (\; Q_{ic}/P_o + 1)^{2/7} - 1 \;] \;]^{1/2}$$

where:

a_o = Standard day, sea level speed of sound, knots = 661.49 knots

P_o = standard day, sea level static pressure, in-Hg = 29.9213 in-Hg

Q_{ic} = instrument corrected differential pressure, in-Hg

7. Calibrated airspeeds (V_{cal}) were obtained by correcting V_{ic} for position error (V_{pc}).

$$V_{cal} = V_{ic} + V_{pc}$$

8. Equivalent airspeeds (V_e) were obtained through the equation:

$$V_e = a_o \; [\; 5\delta \; [\; (\; Q_c / \; P_c + 1 \;)^{2/7} - 1 \;] \;]^{1/2}$$

where:

$\delta = P_c/P_o$

P_c = Ambient test static pressure, in-Hg

Q_c = calibrated differential pressure, in-Hg

$= P_o \; [\; [0.2 \; [V_{cal}/a_o]^2 \; + 1 \;]^{7/2} \; - 1 \;]$

Coefficient of Lift Determination

9. Test lift coefficients were obtained through the equation:

$$C_L = \frac{(2)(W)(n)}{\rho_o \, ((V_e)(1.6878))^2 360}$$

where:

W = aircraft gross weight

n = normal load factor

ρ_o = standard day, sea level density = 0.0023769 (slugs/ft^3)

360= wing surface area, ft^2

AIRSPEED CALIBRATION

10. The test boom pitot-static sytem was calibrated using the aircraft pace method to determine the airspeed position error and is presented in figure 1.

WEIGHT AND BALANCE

11. Prior to flight testing, a weight and balance determination was conducted on the aircraft using calibrated floor scales located under the aircraft landing gear. The aircraft basic weight and center of gravity with standard engine exhaust stacks (Kit A) and test equipment installed, no external stores and empty fuel, was 12,508 lb and FS 163.06.

RIGGING CHECK

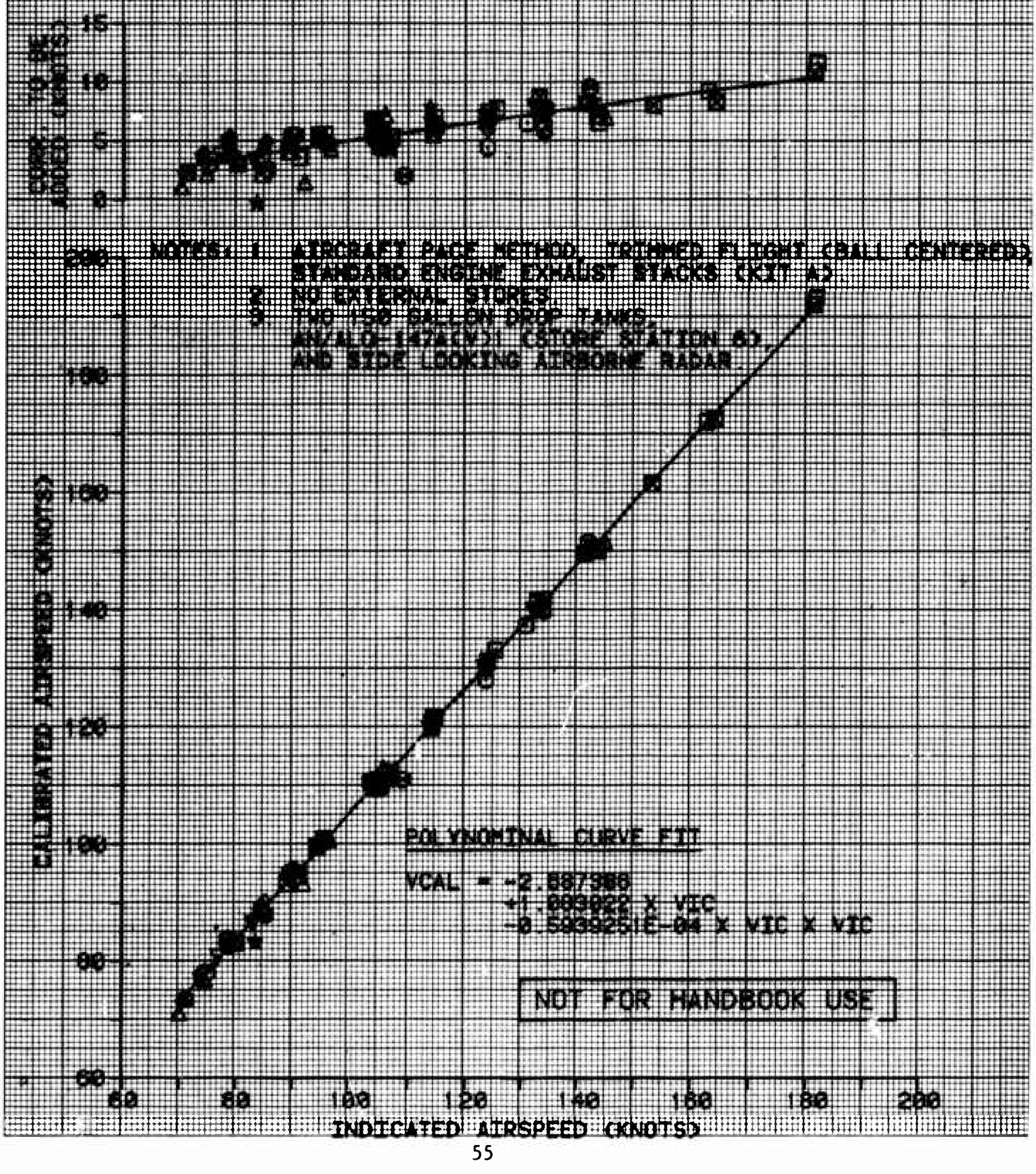
12. Mechanical rigging of engine and flight controls was checked for compliance with applicable Army Maintenance Manuals.

FIGURE I 1

BOOM SYSTEM AIRSPEED CALIBRATION

OV-10(C) USA S/N 62-5867

SYM	GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	PRESSURE ALTITUDE (FT)	OAT (DEG C)	PROP SPEED (RPM)	A/C CONFIG	STORES CONFIG 2
⊡	14,200	164.8(AFT)	1.0	8500	7.0	1400	CR	OFF
⊙	13,800	164.7(AFT)	1.0	9400	6.0	1660	TO	OFF
△	13,800	164.9(AFT)	1.0	9600	4.5	1080	GA	OFF
◇	14,400	164.6(AFT)	1.0	9800	6.5	1650	L	OFF
⊠	17,800	162.3(AFT)	5.1	9000	1.0	1400	CR	ON 3
⊗	16,800	162.2(AFT)	5.4	9600	0.0	1650	TO	ON
▽	17,200	162.9(AFT)	5.3	9700	0.0	1080	GA	ON
★	16,500	162.1(AFT)	5.5	9600	1.0	1640	L	ON



DEFINITIONS

13. Results were categorized as deficiencies or shortcomings in accordance with the following definitions.

Deficiency

14. A defect or malfunction discovered during the life cycle of an item of equipment that constitutdes a safety hazard to personnel; will result in serious damage to the equipment if operation is continued; or indicates improper design or other cause of failure of an item or part, which seriously impairs the equipment's operational capability.

Shortcoming

15. An imperfection or malfunction occurring during the life cycle of equipment which must be reported and which should be corrected to increase efficiency and to render the equipment completely serviceable. It will not cause an immediate breakdown, jeopardize safe operation, or materially reduce the usability of the material or end product.

APPENDIX E. TEST DATA

INDEX

Table 1. Dual-Engine Unaccelerated Stall Peformance Summary
Cruise Configuration

External Stores	LSSS	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Aerodynamic Buffet Airspeed (KIAS)	Stall Airspeed (KIAS/ KCAS)
	OFF	0/0	14400	9100	164.7	105	90/90
	OFF	0/0	14400	9300	164.7	106	91[1]/92
	ON	0/0	14500	8600	164.7	114	90/90
OFF	ON	0/0	14500	10000	164.7	104	90[1]/90
	OFF	87/87	14300	11500	164.6	95	78/74
	OFF	85/87	14200	11600	164.8	93	79[1]/76
	ON	84/89	14600	10800	164.7	96	78/75
	ON	85/88	14300	10600	164.8	98	79[1]/75
	OFF	0/0	17800	11300	163.3	120	99/100
	ON	0/0	17900	9700	163.2	135	98/99
ON[2]	ON	0/0	17900	9500	157.9	126	99/100
	OFF	82/84	17800	12200	163.3	None	88/84
	ON	81/85	17800	11500	163.2	128	90/85
	ON	84/89	17800	11600	157.9	117	91/86

NOTES:
[1]Speed brakes extended.
[2]Two 150 gallon drop tanks, AN/ALQ-147A(V)1 (store station 6), and Side Looking Airborne Radar.

Table 2. Dual-Engine Unaccelerated Stall Performance Summary
Takeoff Configuration

External Stores	LSSS	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Aerodynamic Buffet Airspeed (KIAS)	Stall Airspeed (KIAS/KCAS)
OFF	OFF	0/0	14200	9900	164.6	93	82/81
	ON	0/0	14300	8900	164.6	89	85/83
	OFF	74/75	14100	11800	164.6	None	71/68
	ON	72/76	14100	11300	164.6	None	70/67
ON[1]	OFF	0/0	17400	10400	163.1	95	91/90
	ON	0/0	17700	9300	163.2	107	90/90
	ON	0/0	17700	8100	157.7	105	92/91
	OFF	69/69	17300	11600	163.2	82	80/76
	ON	69/75	17600	12400	163.2	None	83/76
	ON	73/79	17600	11300	157.7	None	81/76

NOTE:

[1]Two 150 gallon drop tanks, AN/ALQ-147A(V)1 (store station 6), and Side Looking Airborne Radar.

Table 3. Dual-Engine Unaccelerated Stall Performance Summary
Go-Around Configuration

External Stores	LSSS	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Aerodynamic Buffet Airspeed (KIAS)	Stall Airspeed (KIAS/ KCAS)
	OFF	0/0	14100	10600	164.8	None	80/78
	ON	0/0	13900	10200	164.9	86	77/77
	OFF	20/26	14000	9700	164.8	None	73/70
OFF	ON	19/25	13900	10000	164.9	None	73/71
	OFF	73/75	14000	12500	164.9	None	69/65
	OFF	73/75	13900	12000	164.9	None	69[1]/66
	ON	72/75	14200	12400	164.8	None	69/67
	ON	72/77	13700	11000	164.8	None	68[1]/65
	OFF	0/0	17400	10600	163.3	94	89/89
	ON	0/0	17400	8600	163.2	107	88/87
	ON	0/0	17500	8900	157.8	101	89/88
	OFF	21/25	17400	10000	163.5	None	83/81
ON[2]	ON	20/25	17400	8500	163.2	92	82/80
	ON	23/24	17400	9100	157.8	92	84/81
	OFF	75/76	16900	10900	163.1	81	75/71
	ON	72/77	17300	11400	163.2	None	80/74
	ON	75/78	17400	11600	157.8	85	79/74

NOTES:

[1]Speed brakes extended.
[2]Two 150 gallon drop tanks, AN/ALQ-147A(V)1 (store station 6), and Side Looking Airborne Radar.

Table 4. Dual-Engine Unaccelerated Stall Performance Summary
Landing Configuration

External Stores	LSSS	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Aerodynamic Buffet Airspeed (KIAS)	Stall Airspeed (KIAS/ KCAS)
OFF	OFF	0/0	13800	9900	164.7	None	78/77
	ON	0/0	13600	9000	164.7	79	75/75
	OFF	22/27	13800	9700	164.7	None	71/68
	ON	20/22	13600	9700	164.7	None	71/68
	OFF	72/75	13700	11900	164.7	76	65/64
	OFF	74/75	13700	11600	164.7	80	66[1]/63
	ON	73/76	13800	11200	164.6	None	66/64
	ON	75/77	13400	9800	164.6	None	63[1]/63
ON[2]	OFF	0/0	17100	9700	163.2	89	85/85
	ON	0/0	17200	8800	163.0	95	84/84
	ON	0/0	17200	8700	157.5	95	88/86
	OFF	21/25	17000	9600	163.2	None	81/77
	ON	23/24	17100	9100	163.1	97	83/80
	ON	21/25	17100	8100	157.5	85	81/77
	OFF	75/76	16900	10900	163.1	79	75/71
	ON	74/79	17000	10600	163.1	None	75/71
	ON	72/77	17100	12300	157.5	79	74/70

NOTES:

[1]Speed brakes extended.
[2]Two 150 gallon drop tanks, AN/ALQ-147A(V)1 (store station 6), and Side Looking Airborne Radar.

Table 5. Dual-Engine Accelerated Stall Performance Summary
Cruise Configuration

External Stores	LSSS	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Normal Acceleration at Stall (g)	Stall Airspeed (KIAS/ KCAS)
OFF	OFF	0/0	14280	8360	164.8	2.04	125/129
	OFF	0/0	14200	10420	164.8	2.52	143/147
	OFF	0/0	14040	8460	164.8	3.20	164/170
	ON	0/0	14500	9880	164.7	2.03	127/129
	ON	0/0	14420	9660	164.7	2.59	145/148
	ON	0/0	14340	9980	164.8	2.86	151/155
	OFF	94/95	13960	10120	164.8	2.03	118/117
	OFF	90/91	13920	11200	164.9	2.42	133/134
	OFF	90/91	13880	11540	164.9	2.76	146/146
	ON	91/92	14100	10060	164.8	1.97	118/117
	ON	91/90	14040	10600	164.8	2.40	132/133
	ON	92/92	13940	10180	164.8	2.65	140/141
ON[1]	OFF	0/0	17180	12540	163.3	1.99	137/140
	OFF	0/0	17100	11160	163.3	2.64	163/171
	OFF	0/0	17040	10980	163.3	2.62	166/174
	ON	0/0	17520	10440	163.2	1.97	138/142
	ON	0/0	17440	9100	163.2	2.34	154/158
	ON	0/0	17340	9560	163.2	2.57	164/170
	OFF	39/90	17480	11260	163.2	1.79	125/124
	OFF	89/91	17420	11160	163.2	2.28	143/145
	OFF	88/90	17260	11920	163.2	2.45	152/154
	ON	84/86	17300	11820	163.2	1.82	126/125
	ON	85/90	17220	11500	163.2	2.18	139/140
	ON	92/94	17140	9860	163.2	2.41	148/148

NOTE:

[1]Two 150 gallon drop tanks, AN/ALQ-147A(V)1 (store station 6), and Side Looking Airborne Radar.

Table 6. Dual-Engine Accelerated Stall Performance Summary
Takeoff Configuration

External Stores	LSSS	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Normal Acceleration at Stall (g)	Stall Airspeed (KIAS/KCAS)
ON[1]	OFF	0/0	17520	10960	163.3	1.76	120/124
	ON	0/0	17800	7100	163.0	1.62	115/117
	OFF	77/79	17400	10880	163.2	1.54	101/99
	ON	71/76	17700	12020	163.0	1.69	112/108

NOTE:

[1]Two 150 gallon drop tanks, AN/ALQ-147A(V)1 (store station 6), and Side Looking Airborne Radar.

Table 7. Single-Engine Unaccelerated Stall Performance Summary
Cruise Configuration

External Stores	LSSS	Engine Torque Lt/Rt (%)[1]	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Aerodynamic Buffet Airspeed (KIAS)	Stall Airspeed (KIAS/ KCAS)
OFF	OFF	0/0[2]	14500	10200	164.7	105	89/89
	ON	0/0[2]	14500	10000	164.7	113	90/90
	OFF	0/72	14500	10400	164.7	114	85/83
	ON	0/71	14400	10600	164.7	112	84/81
	OFF	0/78	14500	9800	164.7	110	88/85
	ON	0/78	14400	10200	164.7	109	85/83
	OFF	0/82	14400	11100	164.7	111	88/86
	ON	0/83	14400	9900	164.8	113	85/82
ON[3]	OFF	0/0[2]	17100	11900	163.3	None	99/100
	ON	0/0[2]	17900	9300	163.2	138	101/102
	ON	0/0[2]	18000	10000	157.9	132	107/107
	OFF	0/72	17000	11300	163.3	118	97/96
	OFF	0/78	16900	10200	163.3	None	97/93
	OFF	0/81	16900	11000	163.3	None	97/94
	ON	0/81	17800	11000	163.2	124	101/99
	ON	0/80	17900	11800	157.9	124	99/98

NOTES:

[1]Zero engine torque is engine shutdown and propeller feathered unless otherwise noted.
[2]Power lever at flight idle and propeller at maximum rpm.
[3]Two 150 gallon drop tanks, AN/ALQ-147A(V)1 (store station 6), and Side Looking Airborne Radar.

Table 8. Single-Engine Unaccelerated Stall Performance Summary
Takeoff Configuration

Stores	LSSS	Engine Lt/Rt (%)[1]	Average Weight (lb)	Average Altitude (ft)	Average Gravity (FS)	Aerodynamic Buffet Airspeed (KIAS)	Stall Airspeed (KIAS/ KCAS)
OFF	OFF	0/0[2]	14400	9800	164.6	None	82/81
	ON	0/0[2]	14200	8900	164.6	96	82/81
	OFF	0/71	14300	12100	164.6	None	83/80
	ON	0/72	14100	11500	164.7	92	77/74
	OFF	0/77	14200	10500	164.6	None	79/76
	ON	0/76	14100	10600	164.7	90	77/74
	OFF	0/80	14100	10500	164.6	None	79/77
	ON	0/81	14100	9900	164.7	92	80/76
ON[3]	OFF	0/0[2]	17800	11300	163.2	None	92/89
	ON	0/0[2]	17700	8000	163.1	106	91/89
	ON	0/0[2]	17800	8500	157.7	108	91/88
	OFF	0/67	17800	10800	163.2	100	92/89
	OFF	0/73	17700	11200	163.2	100	91/89
	OFF	0/81	17800	10200	163.2	None	91/8
	ON	0/80	17500	10100	163.1	103	89/85
	ON	0/82	17600	9600	157.7	103	91/88

NOTES:

[1]Zero engine torque is engine shutdown and propeller feathered unless otherwise noted.
[2]Power lever at flight idle and propeller at maximum rpm.
[3]Two 150 gallon drop tanks, AN/ALQ-147A(V)1 (store station 6), and Side Looking Airborne Radar.

Table 9. Single-Engine Unaccelerated Stall Performance Summary
Go-Around Configuration

External Stores	LSSS	Engine Torque Lt/Rt (%)[1]	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Aerodynamic Buffet Airspeed (KIAS)	Stall Airspeed (KIAS/ KCAS)
	OFF	0/0[2]	14100	9200	164.8	None	79/98
	ON	0/0[2]	14000	9000	164.9	91	81/80
	OFF	0/68	14000	10700	164.8	88	78/76
OFF	ON	0/72	13900	11400	164.9	87	74/71
	OFF	0/74	14000	10700	164.8	84	77/75
	ON	0/78	13900	10600	164.9	None	81/77
	OFF	0/81	13900	10700	164.9	None	81/78
	ON	0/80	13900	10100	164.9	85	82/79
	OFF	0/0[2]	17500	9800	163.3	None	90/89
	ON	0/0[2]	17400	8600	163.2	104	88/88
	ON	0/0[2]	17400	8200	157.8	108	88/89
ON[3]	OFF	0/71	17400	11000	163.4	98	87/86
	OFF	0/74	17300	11500	163.4	None	89/85
	OFF	0/80	17000	10300	163.3	100	91/88
	ON	0/79	17300	10300	163.2	97	86/84
	ON	0/80	17400	10600	157.8	98	84/82

NOTES:

[1]Zero engine torque is engine shutdown and propeller feathered unless otherwise noted.
[2]Power lever at flight idle and propeller at maximum rpm.
[3]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.

Table 10. Single-Engine Unaccelerated Stall Performance Summary
Landing Configuration

External Stores	LSSS	Engine Torque Lt/Rt (%)[1]	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Aerodynamic Buffet Airspeed (KIAS)	Stall Airspeed (KIAS/ KCAS)
OFF	OFF	0/0[2]	13900	9600	164.7	NONE	76/77
	ON	0/0[2]	13800	10100	164.7	83	79/79
	OFF	0/70	13800	10300	164.7	NONE	77/75
	ON	0/71	13700	11800	164.7	86	77/74
	OFF	0/76	13700	10600	164.7	NONE	75/73
	ON	0/77	13700	10200	164.7	83	78/75
	OFF	0/82	13700	10100	164.7	NONE	77/74
	ON	0/76	13600	12000	164.7	84	76/74
ON[3]	OFF	0/0[2]	16600	8800	162.3	NONE	86/84
	ON	0/0[2]	17200	9900	163.0	97	85/85
	ON	0/0[2]	17300	8100	157.6	98	87/87
	OFF	0/69	16900	11500	163.1	NONE	85/83
	OFF	0/75	16800	11400	163.0	NONE	85/83
	OFF	0/81	16700	10000	162.9	NONE	84/82
	ON	0/81	17100	9400	163.1	96	87/82
	ON	0/83	17100	9000	157.5	106	85/82

NOTES:

[1]Zero engine torque is engine shutdown and propeller feathered unless otherwise noted.
[2]Power lever at flight idle and propeller at maximum rpm.
[3]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.

Table 11. Minimum Single-Engine Control Speed Summary
Cruise Configuration

External Stores	LSSS	Average Gross Weight (lb)	Average Center of Gravity (FS)	Average Engine Torque Lt/Rt (%)	Average Propeller Speed (RPM)	Static V_{MC} (KIAS/ KCAS)	Dynamic V_{MC} (KIAS/ KCAS)
OFF	OFF[1]	14,400	164.7	0 /87	1440	86[2]/84	
		14,400	164.7	0 /90	1450	86[2]/84	
		14,400	164.7	0 /99	1480	87[2]/84	
		14,400	164.7	0 /91	1460		94/91
		14,300	164.7	0 /95	1450		94/94
		14,200	164.7	0 /100	1450		95/94
	ON[3]	14,300	164.6	0 /74	1590	84[2]/82	
		14,300	164.6	0 /79	1600	86[2]/84	
		14,300	164.6	0 /84	1600	85[2]/83	
		14,200	164.6	0 /91	1460		92/90
ON[4]	OFF[1]	17,900	163.3	0 /88	1450	97[5]/96	
		17,800	163.3	0 /94	1460	96[5]/94	
		17,700	163.3	0 /99	1460	95[5]/93	
		16,900	163.1	0 /90	1440		103/103
		16,800	163.0	0 /95	1440		102/102
		16,700	163.1	0 /100	1450		101/101
	ON[3]	17,800	163.2	0 /82	1590	100[5]/99	
		16,900	163.1	0 /90	1450		101/101
		17,900	157.9	0 /82	1600	100[5]/99	
		17,000	157.5	0 /94	1450		102/102

NOTES:

[1]Average density altitude = 6,000 ft.
[2]V_{mc} defined by loss of directional control.
[3]Average density altitude = 10,000 ft.
[4]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.
[5]V_{mc} defined by stall.

Table 12. Minimum Single-Engine Control Speed Summary
Takeoff Configuration

External Stores	LSSS	Average Gross Weight (lb)	Average Center of Gravity (FS)	Average Engine Torque Lt/Rt (%)	Average Propeller Speed (RPM)	Static V_{MC} (KIAS/ KCAS)	Dynamic V_{MC} (KIAS/ KCAS)
OFF	OFF[1]	14,300	164.7	0 /77	1640	81[2]/78	
		14,300	164.7	0 /83	1640	81[2]/78	
		14,200	164.7	0 /87	1630	81[2]/77	
		14,200	164.7	0 /86	1650	82[3]/79	
		14,400	164.7	0 /91	1650		84/82
	ON[4]	14,000	164.6	0 /71	1630	77[5]/74	
		14,000	164.6	0 /76	1630	77[5]/74	
		14,000	164.6	0 /82	1640	78[5]/75	
		14,100	164.6	0 /77	1660		83/80
ON[6]	OFF[1]	17,900	163.3	0 /74	1660	89[5]/88	
		17,800	163.3	0 /79	1640	92[5]/87	
		17,700	163.3	0 /84	1670	89[5]/86	
		17,900	163.3	0 /75	1660		92/90
		17,800	163.3	0 /80	1660		92/90
		17,700	163.3	0 /85	1670		92/90
	ON[4]	17,500	163.2	0 /80	1650	90[5]/88	
		16,800	163.1	0 /82	1650		88/86
		16,400	157.5	0 /82	1650	88[5]/86	
		16,800	157.5	0 /82	1640		88/86

NOTES:

[1] Average density altitude = 6,000 ft.
[2] V_{mc} determined by stall and loss of directional control simultaneously.
[3] Landing light extended, V_{mc} determined by stall.
[4] Average density altitude = 10,000 ft
[5] V_{mc} defined by stall.
[6] Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.

Table 13. Minimum Single-Engine Control Speed Summary
Go-Around Configuration

External Stores	LSSS	Average Gross Weight (lb)	Average Center of Gravity (FS)	Average Engine Torque Lt/Rt (%)	Average Propeller Speed (RPM)	Static V_{MC} (KIAS/ KCAS)	Dynamic V_{MC} (KIAS/ KCAS)
OFF	OFF[1]	14,100	164.7	0 /77	1630	78[2]/76	
		14,000	164.7	0 /83	1650	78[2]/75	
		14,000	164.7	0 /88	1630	75[3]/73	
		13,500	164.5	0 /79	1660		80/77
		13,400	164.5	0 /85	1670		77/74
	ON[4]	13,800	164.6	0 /72	1640	74[2]/70	
		13,800	164.6	0 /78	1640	77[2]/74	
		13,700	164.6	0 /79	1650	77[2]/74	
		14,000	164.6	0 /77	1660		80/77
ON[5]	OFF[1]	17,600	163.3	0 /75	1660	85[2]/85	
		17,600	163.3	0 /79	1660	85[2]/85	
		17,500	163.3	0 /84	1650	86[2]/85	
		17,600	163.3	0 /75	1680		87/85
		17,500	163.3	0 /85	1670		88/86
	ON[4]	17,300	163.3	0 /81	1640	85[2]/83	
		17,000	163.1	0 /80	1660		88/86
		17,400	157.6	0 /80	1640	85[2]/83	
		17,700	157.9	0 /81	1640		86/85

NOTES:

[1]Average density altitude = 6,000 ft.
[2]V_{mc} defined by stall.
[3]V_{mc} defined by stall and loss of directional control simultaneously.
[4]Average density altitude = 10,000 ft.
[5]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.

Table 14. Minimum Single-Engine Control Speed Summary
Landing Configuration

External Stores	LSSS	Average Gross Weight (lb)	Average Center of Gravity (FS)	Average Engine Torque Lt/Rt (%)	Average Propeller Speed (RPM)	Static V_{MC} (KIAS/ KCAS)	Dynamic V_{MC} (KIAS/ KCAS)
OFF	OFF[1]	14,000	164.7	0 /76	1630	77[2]/75	
		13,900	164.7	0 /82	1630	75[2]/73	
		13,900	164.7	0 /88	1630	78[2]/75	
		14,100	164.7	0 /80	1650		80/77
		14,000	164.7	0 /90	1660		78/75
	OFF[3]	13,600	164.6	0 /71	1630	77[2]/75	
		13,600	164.6	0 /77	1640	78[2]/75	
		13,500	164.6	0 /78	1630	77[2]/75	
		13,800	164.7	0 /77	1670		79/76
ON[4]	OFF[1]	17,400	163.3	0 /77	1650	85[2]/83	
		16,800	163.1	0 /76	1640	84[2]/82	
		17,300	163.3	0 /87	1640	83[2]/80	
		17,300	163.3	0 /75	1680		85/83
		17,200	163.2	0 /85	1670		85/83
	ON[3]	17,100	163.1	0 /81	1650	84[2]/82	
		16,800	163.1	0 /82	1650		84/82
		17,700	157.9	0 /82	1650	83[2]/80	
		16,500	157.4	0 /78	1650		84/82

NOTES:

[1]Average density altitude = 6,000 ft.
[2]V_{mc} defined by stall.
[3]Average density altitude = 10,000 ft.
[4]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.

Table 15. Dual-Engine Minimum Trim Airspeed Summary[1,2]

Aircraft Configuration	External Stores	LSSS	Average Gross Weight (lb)	Average Center of Gravity (FS)	Minimum Trim Airspeed (KCAS)
Cruise	OFF	OFF	14,000	164.9	105
		ON	14,000	164.8	108
	ON[3]	OFF	17,500	163.2	107
		ON	17,500	163.2	108
			17,500	157.9	112
Takeoff	OFF	OFF	14,000	164.9	89
		ON	14,000	164.8	92
	ON[3]	OFF	17,500	164.8	94
		ON	17,500	163.2	95
			17,500	157.9	95
Go-Around	OFF	OFF	14,000	164.9	87
		ON	14,000	164.8	94
	ON[3]	OFF	17,500	163.2	89
		ON	17,500	163.2	92
			17,500	157.9	92
Landing	OFF	OFF	14,000	164.9	85
		ON	14,000	164.8	90
	ON[3]	OFF	17,500	163.2	84
		ON	17,500	163.2	86
			17,500	157.9	88

NOTES:

[1]Average density altitude = 10,500 feet.
[2]Limiting trim was rudder for all cases.
[3]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.

Table 16. Single-Engine Minimum Trim Airspeeds Summary[1,2]

Aircraft Configuration	External Stores	LSSS	Average Gross Weight (lb)	Average Center of Gravity (FS)	Minimum Trim Airspeed (KCAS)
Cruise	OFF	OFF	14,500	164.9	147
		ON	14,500	164.8	155
	ON[3]	OFF	17,000	163.2	141
		ON	17,500	163.2	146
			17,500	157.9	146
Takeoff	OFF	OFF	14,500	164.9	136
		ON	14,000	164.8	142
	ON[3]	OFF	18,000	164.8	136
		ON	17,500	163.2	132
			17,500	157.9	138
Go-Around	OFF	OFF	14,500	164.9	137
		ON	14,000	164.8	144
	ON[3]	OFF	18,000	163.2	133
		ON	17,500	163.2	136
			17,500	157.9	139
Landing	OFF	OFF	14,500	164.9	138
		ON	14,000	164.8	146
	ON[3]	OFF	18,000	163.2	132
		ON	17,500	163.2	136
			17,500	157.9	132

NOTES:

[1]Average density altitude = 10,500 feet.
[2]Limiting trim was rudder for all cases.
[3]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.

Table 17. Dual-Engine Primary Control Positions and Trim Wheel Positions at Trim[1]

Aircraft Configuration	External Stores	LSSS	Average Gross Weight (lb)	Average Center of Gravity (FS)	Trim[2] Airspeed (KCAS)	Control Positions: Longitudinal (in. from full FWD)	Control Positions: Lateral (in. from full AFT)	Control Positions: Directional (in. from full Lt)	Trim Wheel Positions: Elevator (deg)	Trim Wheel Positions: Aileron (deg)	Trim Wheel Positions: Rudder (deg)
Cruise	OFF	OFF	14,000	164.9	106	4.0	7.7	4.2	1.5 ND[3]	0.0	7.0 RT[4]
		ON	14,000	164.8	106	4.1	7.6	4.0	1.0 ND	2.0 RT	4.5 RT
	ON[5]	OFF	17,500	163.2	114	4.8	7.5	4.2	0.0	0.0	3.5 RT
		ON	17,500	163.2	114	5.0	8.1	4.2	0.0	4.0 RT	8.0 RT
			17,500	157.0	116	6.0	7.0	3.9	1.5 NU[6]	5.0 LT[7]	5.0 RT
Takeoff[8]	OFF	OFF	14,000	164.9	132	3.7	7.5	4.6	0.0	5.0 RT	5.0 RT
		ON	14,000	164.8	132	3.8	7.4	3.3	0.0	5.0 RT	5.0 RT
	ON[5]	OFF	17,500	164.8	132	4.2	7.3	3.9	0.0	3.0 LT	5.0 RT
		ON	17,500	163.2	132	4.3	7.2	4.0	0.0	3.0 LT	5.0 RT
			17,500	157.9	132	5.2	7.2	4.2	0.0	3.0 LT	5.0 RT
Go-Around	OFF	OFF	14,000	164.9	93	3.8	6.5	4.0	1.0 ND	0.0	4.0 RT
		ON	14,000	164.8	93	3.8	7.2	4.2	1.0 ND	1.0 RT	5.0 RT
	ON[5]	OFF	17,500	163.2	103	4.5	7.1	4.1	0.0	5.0 LT	1.0 RT
		ON	17,500	163.2	104	4.6	7.0	4.0	0.0	6.0 LT	0.0
			17,500	163.2	104	6.0	7.0	4.2	3.5 NU	5.0 LT	4.0 RT
Landing	OFF	OFF	14,000	164.9	90	3.8	7.0	4.5	0.5 ND	0.0	5.0 RT
		ON	14,000	164.8	89	3.8	7.2	4.4	0.5 ND	1.0 RT	5.0 RT
	ON[5]	OFF	17,500	163.2	99	4.4	7.1	4.3	0.0	5.0 LT	5.0 RT
		ON	17,500	163.2	98	4.6	7.0	4.4	1.0 NU	6.0 LT	2.0 RT
			17,500	157.9	104	5.8	7.1	4.2	2.5 NU	5.0 LT	1.0 RT

NOTES:

[1]Average density altitude = 10,500 feet.
[2]Trim airspeed defined as 1.2 times the dual-engine power OFF stall speed for a specific configuration.
[3]Nose down
[4]Right
[5]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.
[6]Nose up
[7]Left
[8]Primary control positions at trim taken at 132 KCAS and operator's manual recommended trim wheel settings

Table 18. Single-Engine Primary Control Positions and Trim Wheel Positions at Trim[1]

Aircraft Configuration	External Stores	LSSS	Average Gross Weight (lb)	Average Center of Gravity (FS)	Trim[2] Airspeed (KCAS)	Control Positions: Longitudinal (in. from full FWD)	Control Positions: Lateral (in. from full AFT)	Control Positions: Directional (in. from full Lt)	Trim Wheel Positions: Elevator (deg)	Trim Wheel Positions: Aileron (deg)	Trim Wheel Positions: Rudder (deg)
Cruise	OFF	OFF	14,500	164.7	127	4.0	7.8	4.8	1.5 ND[3]	0.0	15.0 RT[4]
		ON	14,000	164.8	122	4.3	8.7	4.8	1.5 ND	10.0 RT	15.0 RT
	ON[5]	OFF	17,500	163.3	134	4.5	8.0	5.1	1.0 ND	2.5 RT	15.0 RT
		ON	17,500	163.1	130	4.7	8.2	4.9	1.0 ND	4.0 RT	15.0 RT
			17,500	157.7	130	5.5	8.5	5.3	1.0 NU[6]	7.0 RT	15.0 RT
Takeoff	OFF	OFF	14,500	164.7	94	3.7	8.5	7.5	1.5 ND	10.0 RT	15.0 RT
		ON	14,000	164.8	94	3.6	9.1	7.5	3.5 ND	15.0 RT	15.0 RT
	ON[5]	OFF	18,000	163.1	107	4.7	8.6	6.0	0.5 ND	1.0 LT[7]	15.0 RT
		ON	17,500	163.1	106	5.1	7.8	6.1	0.5 ND	4.0 RT	15.0 RT
			17,500	157.7	106	6.5	8.2	6.3	2.5 NU	10.0 RT	15.0 RT
Go-Around	OFF	OFF	14,500	164.7	113	3.5	7.9	5.6	2.5 ND	5.0 RT	15.0 RT
		ON	14,000	164.8	108	3.5	8.1	5.6	2.5 ND	8.0 RT	15.0 RT
	ON[5]	OFF	18,000	163.1	121	4.0	7.6	5.1	1.0 ND	1.0 LT	15.0 RT
		ON	17,500	163.1	118	4.3	7.8	5.2	1.0 ND	0.0	15.0 RT
			17,500	157.7	118	5.4	7.6	5.4	1.0 NU	0.0	15.0 RT
Landing	OFF	OFF	14,500	164.7	93	3.3	8.3	6.8	3.0 ND	15.0 RT	15.0 RT
		ON	14,000	164.8	93	3.1	8.7	5.7	3.5 ND	15.0 RT	15.0 RT
	ON[5]	OFF	18,000	163.1	104	4.0	7.7	5.8	1.0 ND	2.0 RT	15.0 RT
		ON	17,500	163.1	105	4.2	7.8	5.4	1.0 ND	3.0 RT	15.0 RT
			17,500	157.7	105	5.7	7.8	5.7	2.0 NU	0.0	15.0 RT

NOTES:

[1]Average density altitude = 10,500 feet.
[2]Trim airspeed defined as the operator's manual single engine best rate of climb airspeed.
[3]Nose down
[4]Right
[5]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.
[6]Nose up
[7]Left

Table 19. Dual-Engine Unaccelerated Stall Warning Summary[1]
Cruise Configuration

External Stores	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Artificial Stall Warning Airspeed (KIAS/KCAS)	Stall Airspeed (KIAS/ KCAS)
ON[2]	86/89	17600	11300	157.0	101/100	90/88
	86/91	17100	11300	163.0	101/100	86/84
ON[3]	80/85	16000	11200	160.4	94/93	80/77
OFF	0/0	14300	11200	159.9	100/99	90/88

NOTES:

[1]Louvered Scarfed Shroud Suppressor installed.
[2]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.
[3]Two 150 gallon drop tanks.

Table 20. Dual-Engine Unaccelerated Stall Warning Summary[1]
Takeoff Configuration

External Stores	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Artificial Stall Warning Airspeed (KIAS/KCAS)	Stall Airspeed (KIAS/KCAS)
ON[2]	0/0	17900	11300	157.0	102/101	94/83
	75/77	17800	11300	157.0	94/93	81/78
	0/0	18000	11300	163.0	103/103	94/93
	75/79	17900	11300	163.0	95/94	82/79
ON[3]	0/0	17100	11200	160.4	100/99	90/80
	73/78	17000	11200	160.4	91/89	75/71
OFF	0/0	14200	11200	159.9	93/92	82/79
	72/75	14100	11200	159.9	81/78	67/62

NOTES:

[1]Louvered Scarfed Shroud Suppressor installed.
[2]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.
[3]Two 150 gallon drop tanks.

Table 21. Dual-Engine Unaccelerated Stall Warning Summary[1]
Landing Configuration

External Stores	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Artificial Stall Warning Airspeed (KIAS/KCAS)	Stall Airspeed (KIAS/ KCAS)
ON[2]	0/0	17700	11300	157.0	98/97	90/88
	76/79	17600	11300	157.0	94/93	78/75
	0/0	17800	11300	163.0	99/98	88/86
	77/81	17800	11300	163.0	92/90	76/73
ON[3]	0/0	16900	11200	160.4	96/95	85/83
	72/77	16900	11200	160.4	89/87	72/68
OFF	0/0	14100	11200	159.9	88/86	77/74
	74/79	14000	11200	159.9	76/73	62/57

NOTES:

[1]Louvered Scarfed Shroud Suppressor installed.
[2]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.
[3]Two 150 gallon drop tanks.

Table 22. Single-Engine Unaccelerated Stall Warning Summary[1]
Cruise Configuration

External Stores	Engine Torque Lt/Rt (%)[2]	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Artificial Stall Warning Airspeed (KIAS/KCAS)	Stall Airspeed (KIAS/ KCAS)
ON[3]	0/0[4]	17500	11300	157.0	110/110	100/99
	0/82	17400	11300	157.0	104/104	99/98
	0/0[4]	17500	11300	163.0	110/110	99/98
	0/79	17500	11300	163.0	104/104	97/96
	0[4]/85	17700	11300	163.0	102/101	100/99
	79/0[4]	17600	11300	163.0	106/106	96/95
ON[5]	0/0[4]	16600	11200	160.4	105/105	97/96
	0/77	16600	11200	160.4	100/99	89/87
	0[4]/77	16800	11200	160.4	100/99	91/89
	73/0[4]	16800	11200	160.4	103/103	93/92
OFF	0/0[4]	14900	11200	159.9	102/101	91/89
	0/79	14800	11200	159.9	97/96	84/82
	0[4]/77	15000	11200	159.9	96/95	86/84
	73/0[4]	15000	11200	159.9	96/95	86/84

NOTES:

[1]Louvered Scarfed Shroud Suppressor installed.
[2]Zero engine torque is engine shutdown and propeller feathered unless otherwise noted.
[3]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.
[4]Power lever at flight idle and propeller at maximum rpm.
[5]Two 150 gallon drop tanks.

Table 23. Single-Engine Unaccelerated Stall Warning Summary[1]
Takeoff Configuration

External Stores	Engine Torque Lt/Rt (%)[2]	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Artificial Stall Warning Airspeed (KIAS/KCAS)	Stall Airspeed (KIAS/KCAS)
ON[3]	0/0[4]	17400	11300	157.0	106/106	94/93
	0/0[4]	17400	11300	163.0	103/103	93/92
	73/0	17400	11300	163.0	100/99	88/86
ON[5]	0/0[4]	16500	11200	160.4	99/98	90/88
OFF	0/0[4]	14600	11200	159.9	96/95	83/80

NOTES:

[1]Louvered Scarfed Shroud Suppressor installed.
[2]Zero engine torque is engine shutdown and propeller feathered unless otherwise noted.
[3]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.
[4]Power lever at flight idle and propeller at maximum rpm.
[5]Two 150 gallon drop tanks.

Table 24. Single-Engine Unaccelerated Stall Warning Summary[1]
Go-Around Configuration

External Stores	Engine Torque Lt/Rt (%)[2]	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Artificial Stall Warning Airspeed (KIAS/KCAS)	Stall Airspeed (KIAS/KCAS)
ON[3]	76/0	17200	11300	157.0	101/100	90/88
ON[4]	67/0	16400	11200	160.4	94/93	82/79
OFF	0/77	14800	11200	159.9	90/88	77/74
	73/0	14600	11200	159.9	90/88	76/73

NOTES:

[1]Louvered Scarfed Shroud Suppressor installed.
[2]Zero engine torque is engine shutdown and propeller feathered.
[3]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar (SLAR).
[4]Two 150 gallon drop tanks.

Table 25. Single-Engine Unaccelerated Stall Warning Summary[1]
Landing Configuration

External Stores	Engine Torque Lt/Rt (%)[2]	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Artificial Stall Warning Airspeed (KIAS/KCAS)	Stall Airspeed (KIAS/KCAS)
ON[3]	0/0[4]	16200	11200	160.4	94/93	82/79
	0/78	16200	11200	160.4	94/93	80/77
OFF	0/0[4]	14700	11200	159.9	92/90	79/76
	0/77	14700	11200	159.9	86/84	77/74

NOTES:

[1]Louvered Scarfed Shroud Suppressor installed.
[2]Zero engine torque is engine shutdown and propeller feathered unless otherwise noted.
[3]Two 150 gallon drop tanks.
[4]Power lever at flight idle and propeller at maximum rpm.

Table 26. Dual-Engine Accelerated Stall Warning Summary[1]
Cruise Configuration

External Stores	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Lift Coefficient at Artificial Stall Warning (Nondimensional)	Lift Coefficient at Stall (Nondimensional)
ON[2]	0/0	17100	8500	157.0	1.15	1.53
	86/91	17000	8500	157.0	1.29	1.42
	0/0	17000	8500	163.0	1.22	1.36
	88/93	17000	8500	163.0	1.33	1.55
	90/92	16900	8500	163.0	1.37	1.54
ON[3]	0/0	15800	9600	160.4	1.23	1.43
	81/87	15700	9600	160.4	1.38	1.78
OFF	0/0	14400	9600	159.9	1.25	1.53
	78/85	14400	9600	159.9	1.39	1.97

NOTES:

[1]Louvered Scarfed Shroud Suppressor installed.
[2]Two 150 gallon drop tanks, AN/ALQ-147A (V)1 (store station 6), and Side Looking Airborne Radar.
[3]Two 150 gallon drop tanks.

Table 27. Dual-Engine Accelerated Stall Warning Summary[1]
Takeoff Configuration

External Stores	Engine Torque Lt/Rt (%)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Center of Gravity (FS)	Artificial Stall Warning Lift Coefficient (Nondimensional)	Stall Lift Coefficient (Nondimensional)
ON[2]	0/0	16900	8500	157.0	1.30	1.73
	72/79	16800	8500	157.0	1.66	1.86
	0/0	16800	8500	163.0	1.53	1.79
	78/83	16800	8500	163.0	1.65	2.10
ON[3]	0/0	15600	9600	160.4	1.46	1.79
	74/79	15600	9600	160.4	1.72	2.10
OFF	0/0	14400	9600	159.9	1.57	1.82
	73/76	14300	9600	159.9	1.82	1.97

NOTES:

[1]Louvered Scarfed Shroud Suppressor installed.
[2]Two 150 gallon drop tanks, AN/ALQ-147(V)1 (store station 6), and Side Looking Airborne Radar.
[3]Two 150 gallon drop tanks.

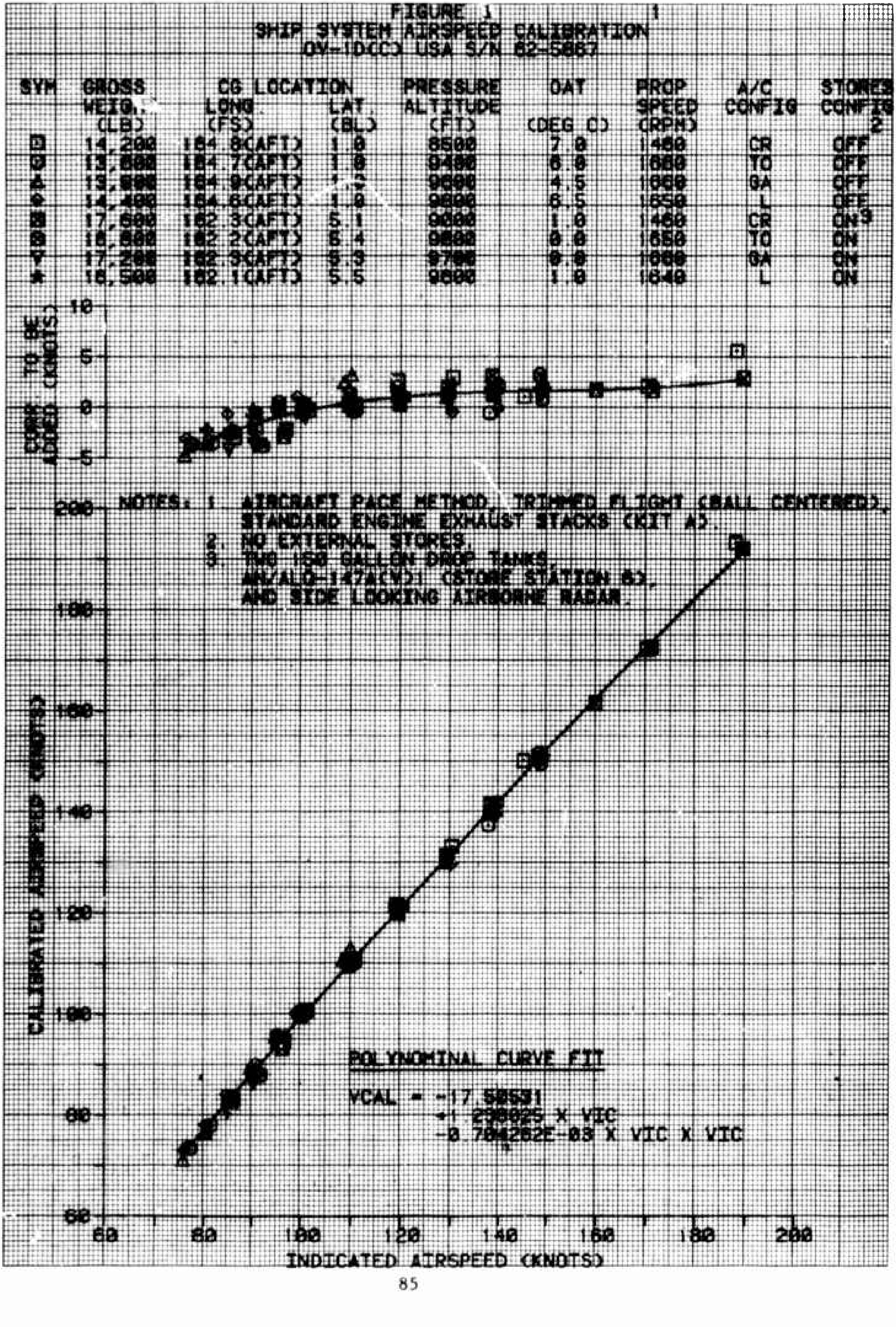


FIGURE 1
SHIP SYSTEM AIRSPEED CALIBRATION
OV-1D(C) USA S/N 62-5867
SYM GROSS WEIGHT (LB) CG LOCATION LONG (FS) LAT (BL) PRESSURE ALTITUDE (FT) OAT (DEG C) PROP SPEED (RPM) A/C CONFIG STORES CONFIG 2
14,200 164.8(AFT) 1.0 8500 7.0 1460 CR OFF
13,600 164.7(AFT) 1.0 9400 6.0 1600 TO OFF
13,000 164.9(AFT) 9600 4.5 1600 GA OFF
14,400 164.6(AFT) 1.0 9800 6.5 1650 L OFF
17,600 162.3(AFT) 5.1 9000 1.0 1460 CR ON 3
16,600 162.2(AFT) 5.4 9800 0.0 1650 TO ON
17,200 162.3(AFT) 5.3 9700 0.0 1600 GA ON
16,500 162.1(AFT) 5.5 9600 1.0 1640 L ON
CORR. TO BE ADDED (KNOTS)
10
5
0
-5
NOTES: 1. AIRCRAFT PACE METHOD, TRIMMED FLIGHT (BALL CENTERED), STANDARD ENGINE EXHAUST STACKS (KIT A).
2. NO EXTERNAL STORES.
3. TWO 150 GALLON DROP TANKS, AN/ALQ-147A(V)1 (STORE STATION 6), AND SIDE LOOKING AIRBORNE RADAR.
CALIBRATED AIRSPEED (KNOTS)
200
180
160
140
120
100
80
60
POLYNOMINAL CURVE FIT
VCAL = -17.50531
+1.230025 X VIC
-0.704282E-03 X VIC X VIC
60 80 100 120 140 160 180 200
INDICATED AIRSPEED (KNOTS)

DISTRIBUTION

HQDA (DALO-AV, DALO-FDQ, DAMO-HRS, DAMA-PPM-T, DAMA-RA, DAMA-WSA)	6
US Army Materiel Command (AMCDE-SA, AMCDE-P, AMCQA-SA, AMCQA-ST)	4
US Army Training and Doctrine Command (ATCD-T, ATCD-B)	2
US Army Aviation Systems Command (AMSAV-8, AMSAV-ED, AMSAV-Q, AMSAV-MC, AMSAV-ME, AMSAV-L, AMSAV-N, AMSAV-GTD)	15
US Army Test and Evaluation Command (AMSTE-TE-V, AMSTE-TE-O)	2
US Army Logistics Evaluation Agency (DALO-LEI)	1
US Army Materiel Systems Analysis Agency (AMXSY-RV, AMXSY-MP)	8
US Army Operational Test and Evaluation Agency (CSTE-AVSD-E)	2
US Army Armor School (ATSB-CD-TE)	1
US Army Aviation Center (ATZQ-D-T, ATZQ-CDC-C, ATZQ-TSM-A, ATZQ-TSM-S, ATZQ-TSM-LH)	5
US Army Combined Arms Center (ATZL-TIE)	1
US Army Safety Center (PESC-SPA, PESC-SE)	2
US Army Cost and Economic Analysis Center (CACC-AM)	1
US Army Aviation Research and Technology Activity (AVSCOM) NASA/Ames Research Center (SAVRT-R, SAVRT-M (Library)	3
US Army Aviation Research and Technology Activity (AVSCOM) Aviation Applied Technology Directorate (SAVRT-TY-DRD SAVRT-TY-TSC (Tech Library)	2

US Army Aviation Research and Technology Activity (AVSCOM) Aeroflightdynamics Directorate (SAVRT-AF-D)	1
US Army Aviation Research and Technology Activity (AVSCOM) Propulsion Directorate (SAVRT-PN-D)	1
Defense Technical Information Center (FDAC)	2
US Military Academy, Department of Mechanics (Aero Group Director)	1
ASD/AFXT, ASD/ENF	2
US Army Aviation Development Test Activity (STEBG-CT)	2
Assistant Technical Director for Projects, Code: CT-24 (Mr. Joseph Dunn)	2
6520 Test Group (ENML)	1
Commander, Naval Air Systems Command (AIR 5115B, AIR 5301)	3
Defense Intelligence Agency (DIA-DT-2D)	1
US Army Aviation Systems Command, (AMCPM-AET)	4
Grumman Aircraft Systems Division (Mr. Cliff Fenwick)	1
Grumman Aircraft Systems (Mr. Ed Oelrich)	1
Grumman Aircraft Systems (Mr. Paul Donovon)	1
Grumman Aircraft Systems (Mr. Paul Pellicano)	1